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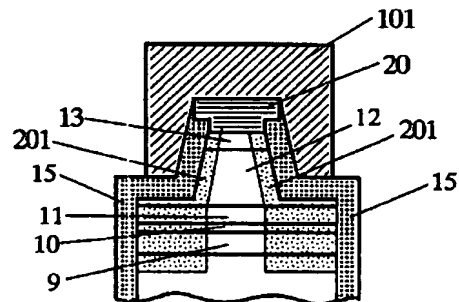
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(54) 【発明の名称】 窒化物半導体レーザ素子

(57) 【要約】

【課題】 素子の絶縁性を良好にして、リーク電流の防止やショートを防止し寿命特性の良好な素子を歩留まりよく得ることができる窒化物半導体レーザ素子を提供することである。

【解決手段】 基板上に、n型窒化物半導体層、活性層及びp型窒化物半導体層を成長させてなる素子構造を有し、p型窒化物半導体層側からエッチングによりリッジ形状のストライプが形成されてなり、さらに少なくとも前記リッジ形状のストライプの側面に絶縁膜15が形成されてなる窒化物半導体レーザ素子で、前記絶縁膜15と接している少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面付近に、アルミニウム又はホウ素を豊富に含有するリッチ層201を有する。



## 【特許請求の範囲】

【請求項1】 基板上に、少なくともn型窒化物半導体層、活性層及びp型窒化物半導体層を成長させてなる素子構造を有し、p型窒化物半導体層側からエッチングによりリッジ形状のストライプが形成されてなり、さらに少なくとも前記リッジ形状のストライプの側面に絶縁膜が形成されてなる窒化物半導体レーザ素子において、前記絶縁膜と接している少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面付近に、アルミニウム又はホウ素を豊富に含有するリッチ層を有することを特徴とする窒化物半導体レーザ素子。

【請求項2】 前記リッチ層が、リッジ形状のストライプを形成後、露出されている少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面に、アルミニウム又はホウ素を拡散させることにより形成されてなることを特徴とする請求項1に記載の窒化物半導体レーザ素子。

【請求項3】 前記リッチ層が、リッジ形状のストライプを形成後、露出されている少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面に、アルミニウム又はホウ素をイオン注入して形成されてなることを特徴とする請求項1に記載の窒化物半導体レーザ素子。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】本発明は窒化物半導体 ( $In_{1-a}Al_aGa_{1-a-b}N$ ,  $0 \leq a$ ,  $0 \leq b$ ,  $a+b \leq 1$ ) よりなるレーザ素子に関し、特に絶縁性が良好でリーク電流とショート防止された寿命の長い窒化物半導体レーザ素子に関する。

## 【0002】

【従来の技術】近年、窒化物半導体レーザ素子の実用化のために多くの研究開発が行われており、種々の窒化物半導体レーザ素子が知られている。例えば、本発明者等は、実用可能なレーザ素子として、Jpn.J.Appl.Phys.Vol.37(1998) pp.L309-L312, Part2, No.3B, 15 March 1998に、サファイア基板上部に、ELOG (Epitaxially laterally overgrown GaN) を  $20 \mu m$  形成し、その後GaNを膜厚が  $100 \mu m$  になるまで成長させた後、サファイア基板を削除することで、約  $80 \mu m$  の転位の低減されたGaN基板を得て、このGaN基板上にレーザ素子構造となる窒化物半導体層を複数積層してなる窒化物半導体レーザ素子を発表している。そして、このレーザ素子は、室温での連続発振1万時間以上を可能とする窒化物半導体レーザ素子を発表した。図6に、上記J.J.A.P.に示されるレーザ素子と同様の模式的断面図を示した。この図6に示されるように、p-GaNよりなるp型コンタクト層からp-Al<sub>0.14</sub>Ga<sub>0.86</sub>N/GaNの超格子構造より

なるp型クラッド層まで部分的にエッチングして形成されたリッジ形状のストライプを有し、形成されたリッジ形状のストライプの側面には素子の絶縁性のためにSiO<sub>2</sub>からなる絶縁膜が形成され、さらに前記ストライプ上部にp電極が形成され、劈開により共振面を形成してなる窒化物半導体レーザ素子である。更にこのレーザ素子は、p電極を覆うようにpパッド電極が形成されている。このようにリッジ形状のストライプの側面に絶縁膜が形成されていることにより、ショートの防止及びリーク電流の防止を行っている。

## 【0003】

【発明が解決しようとする課題】しかしながら、得られたレーザ素子の中には、同一条件で形成されたレーザ素子であるにもかかわらず、極端に寿命特性が悪いものが生じる。本発明者は、極端に寿命特性が低下する原因について種々検討した結果、リッジ形状のストライプの側面の絶縁膜の絶縁が不完全なために、リーク電流が生じたり、ショートが発生するためではないかと推測した。レーザ素子を商品化するにあたっては、寿命特性等の素子特性を良好にすると共に、歩留まりの向上を達成することが望まれる。

【0004】そこで、本発明の目的は、素子の絶縁性を良好にして、リーク電流の防止やショートを防止し寿命特性の良好な素子を歩留まりよく得ることができる窒化物半導体レーザ素子を提供することである。

## 【0005】

【課題を解決するための手段】即ち、本発明の目的は、下記(1)～(3)の構成により達成することができる。

(1) 基板上に、少なくともn型窒化物半導体層、活性層及びp型窒化物半導体層を成長させてなる素子構造を有し、p型窒化物半導体層側からエッチングによりリッジ形状のストライプが形成されてなり、さらに少なくとも前記リッジ形状のストライプの側面に絶縁膜が形成されてなる窒化物半導体レーザ素子において、前記絶縁膜と接している少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面付近に、アルミニウム又はホウ素を豊富に含有するリッチ層を有することを特徴とする窒化物半導体レーザ素子。

(2) 前記リッチ層が、リッジ形状のストライプを形成後、露出されている少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面に、アルミニウム又はホウ素を拡散させることにより形成されてなることを特徴とする前記(1)に記載の窒化物半導体レーザ素子。

(3) 前記リッチ層が、リッジ形状のストライプを形成後、露出されている少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面に、アルミニウム又はホウ素をイオン注入して形成されてなることを特徴とする前記(1)に記載の窒化物

半導体レーザ素子。

【0006】つまり、本発明は、リッジ形状のストライプの側面等の表面付近に、アルミニウム又はホウ素を豊富に含有させてなるリッチ層を、表面から内部に向かって形成することにより、リッジ形状のストライプの側面に形成される絶縁膜と相乗的に作用して良好な絶縁が可能となり、リーク電流及びショートを良好に防止することが可能となる窒化物半導体レーザ素子を提供することができる。さらに、本発明は、リッチ層を有するレーザ素子とすることで、歩留まりの向上をも達成することが

【0007】従来、リッジ形状のストライプの側面には、図6に示すように絶縁性の絶縁膜が形成されている。しかし、この絶縁膜が均一な良好な膜でない場合が生じてしまい絶縁性が不完全となりショートなどが発生してしまう。

【0008】これに対して、本発明者は、パッド電極と接する箇所の絶縁性をより一層完全なものにすべく種々検討した結果、アルミニウム(A1)又はホウ素(B)をストライプの側面及びストライプの側面から連続して

【0009】さらに、本発明において、リッチ層が、リッジ形状のストライプを形成後、露出されているリッジ形状のストライプの側面などの表面に、アルミニウム又はホウ素を拡散させることにより、又はアルミニウム又はホウ素をイオン注入することにより形成されてなるとリッチ層を良好に形成することができ、より良好な絶縁性を示すと共に歩留まりの向上の点で好ましい。

【0010】また、本発明において、A1又はBを拡散やイオン注入すると、その部分の屈折率が小さくなり光の閉じ込めの点でも好ましい。このことから、例えば図6のレーザ素子は、p電極がp型コンタクト層の表面全面に接していないので、実効屈折率導波路型であるが、図6のレーザ素子に、図1に示すように、活性層9の側面までA1またはBを拡散又はイオン注入して、リッチ層201を形成することにより光閉じこめが良好となることで完全屈折率導波路型となり、水平横モードが安定化してしきい値の上昇を防止でき、寿命特性を向上させることができ好ましい。

【0011】

【発明の実施の形態】以下に図1～図4を用いて本発明をさらに詳細に説明する。図1は、前記従来技術で示した図6のレーザ素子に、本発明のリッチ層201を形成してなる一実施の形態である窒化物半導体レーザ素子のリッジ形状のストライプの長さ方向に垂直に切断した一部分を示す模式的断面図である。図2～図4は、完全屈

折率導波路型となるレーザ素子に本発明のリッチ層201を形成してなる一実施の形態である窒化物半導体レーザ素子の模式的断面図である。

【0012】本発明の窒化物半導体レーザ素子は、リッジ形状のストライプの側面に絶縁膜が形成されてなる窒化物半導体レーザ素子において、絶縁膜と接している少なくともリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面付近に、アルミニウム又はホウ素を豊富に含有するリッチ層を有する。従って、リッチ層を形成するレーザ素子としては、特に限定されず、リッジ形状のストライプを有するレーザ素子であればよく、例えば具体的には、図1～図4のレーザ素子が挙げられる。

【0013】まず、図1を用いて、リッチ層201について説明する。図1には、リッジ形状のストライプの側面に絶縁膜が形成され、ストライプの最上層にp電極20が形成され、p電極と電気的に接触するようにpパッド電極がストライプの上方部分に形成されている。そして、素子構造と絶縁膜62の接しているリッジ形状のストライプの側面及びストライプの側面から連続している平面の表面付近にリッチ層201が形成されている。この図1の場合のリッチ層201の形成は、従来の素子の形成の工程において、リッジ形状のストライプを形成後に、p型窒化物半導体層の最上面(p型コンタクト層の表面)にリッチ層201が形成されないように保護した後で、拡散やイオン注入によりA1又はBを露出されている表面付近に豊富に含有させる。

【0014】本発明において、表面付近とは、リッジ形状のストライプを形成した後、露出している素子構造の表面から内側に向かって深さを持っている部分を示す。例えば、図1～4に示されるリッチ層201の形成されている部分を示す。また、本発明において、豊富に含有するとは、例えば図2のp型コンタクト層及びp型クラッド層のように、同一層でありながら他の部分より多くA1又はBを含有していて、A1やBが偏在している状態を示す。そして、A1やBの偏在している部分を本発明ではリッチ層201としている。

【0015】本発明において、リッチ層201の形成は、リッジ形状のストライプを形成した後、露出している部分に、特にpパッド電極が上方部分に形成される箇所の表面付近に、A1又はBを豊富に含有させることで形成される。本発明において、A1やBを豊富に含有させる方法としては、特に限定されないが、例えば好ましい具体例としては、リッチ層を形成したい部分にA1やBを蒸着させた後に熱を加えて拡散させる方法、又はイオン注入による方法などが挙げられる。

【0016】本発明において、拡散させる方法としては、拡散されたい部分にA1又はBを蒸着させ、熱処理を行う。熱処理の際の温度としては、適宜調整され、例えば400℃～700℃である。熱処理の時間として

は、適宜調整され、例えば10分～2時間である。また、リッジ層201の形成を拡散により行う場合、濃度の調整や、表面からの深さの調節は、熱処理の温度と時間を調整することで行われる。

【0017】本発明において、イオン注入させる方法としては、注入させたくない部分をSi酸化膜又はレジストなどでマスクし、ウエハ全面にイオン化させたA1またはBを10～数百keVのエネルギーに加速して表面に打ち込むことで行われる。また、リッジ層201の形成をイオン注入により行う場合、濃度の調整や、表面からの深さの調節は、加速電圧を注入時間を調整することで行われる。

【0018】また、リッジ層201のA1やBの濃度としては、特に限定されなが、絶縁性のとれる程度であり、例えば具体的には $1 \times 10^{14} \text{ atom/cm}^3$ 以上である。また、リッジ層201の膜厚（表面からの深さ）は、特に限定されないが、絶縁性のとれる程度であり、例えば具体的には100オングストローム～2 $\mu\text{m}$ である。

【0019】例えば、リッジ層201の形成の一実施の形態としては、前記従来技術で示したJ. J. A. P. に記載されているように、基板上にn型コンタクト層、活性層、p型コンタクト層等を成長させてなる素子構造を形成後、p型窒化物半導体層側からエッチング等によりリッジ形状のストライプを形成後、リッジ形状のストライプの最上層の表面にリッジ層が形成されないようにした状態で（例えばエッチングの際に形成されたレジスト等の保護膜の形成されている状態で）、露出されている少なくともリッジ形状のストライプの側面などに上記に示した拡散やイオン注入によってリッジ層201を形成する。その後、前記J. J. A. P. 等と同様に絶縁膜15、p電極20及びpパッド電極101等を形成する。そして、図1に示されるリッジ層201を有するレーザ素子となる。図1の絶縁膜62としては、特に限定されないが、SiO<sub>2</sub>等を用いることができる。また、図1のリッジ形状のストライプとしては、特に限定されないが、例えば前記で示したJ. J. A. P. に記載されている内容と同様の内容が挙げられる。

【0020】図1に示すレーザ素子は、リッジ層201を形成することにより、リッジ層201と絶縁膜15とが相乗的に作用して絶縁性が良好となり、リーク電流の防止及びショート防止ができ、寿命特性の良好なレーザ素子となる。さらに図1に示すレーザ素子は歩留まりよく作製することができ、量産する際に好ましい。またさらに、本発明のレーザ素子は絶縁性が良好となるので、素子の信頼性の向上（不良防止）の点でも好ましい。また、図1に示されるレーザ素子は、p電極がp型コンタクト層の表面全面に接していないので、リッジ層201を形成していない状態ではリッジ形状のストライプ内部で電流密度にムラが生じ、水平横モードが不安定とな

りしきい値の上昇が見られる場合があるが、A1又はBを含有させることでその部分の屈折率が小さくなり、光閉じこめが良好となることで、完全屈折率導波路型のレーザ素子のような素子特性を示し易くなる。このように、しきい値の上昇が抑えられれば、寿命特性をより良好にすることができる。図1に示されるリッジ層201は、基板に対して水平方向の膜厚と、垂直方向の膜厚が異なるが、リッジ層201を形成する際の拡散又はイオン注入の条件により適宜調節することで膜厚を調整できる。ここでリッジ層の膜厚とは、A1又はBが素子構造内にどの程度の深さまで入り込んでいるかを示している。

【0021】次に、図2～図4のレーザ素子について説明する。図2～図4は、p型コンタクト層の表面全面がp電極を接している且つストライプ幅が狭いので、水平横モードが安定化し、しきい値の上昇を抑えられるので好ましく、さらに完全屈折率導波路型のレーザ素子として好ましい構造となる。図2～図5には、基板上に、n型コンタクト層5～p型コンタクト層13が積層成長され、このp型コンタクト層側からエッチングによりリッジ形状のストライプを形成し、リッジ形状のストライプの側面に第2の保護膜62（本発明の絶縁膜に相当する絶縁性の膜）が形成され、ストライプの最上層であるp型コンタクト層に接するようにp電極、さらにp電極に接するようにpパッド電極が形成されてなるレーザ素子である。ここで、第2の保護膜62は、絶縁性の膜であり本発明の絶縁膜に相当し、図1の絶縁膜15と同様に素子の絶縁性を維持するために形成されるが、図2～図5の形成の段階を説明するに際して第2の保護膜62とする。そして、このような図2～図5には、各図に示されているように、リッジ形状のストライプの側面及びストライプの側面から連続している平面に、本発明のリッジ層201が形成されている。リッジ層201が形成されることにより、リッジ層201の部分も絶縁性を示し、ストライプの側面に形成されている絶縁性の第2の保護膜62と相乗的に作用して素子の絶縁性を良好にする。絶縁性が良好となることで、リーク電流の防止及びショートの防止が良好となり、寿命特性の向上及び歩留まりの向上が達成できる。

【0022】図2～図5に用いられる絶縁膜となる第2の保護膜62としては、特に限定されないが、例えば、Ti、V、Zr、Nb、Hf、Taよりなる群から選択された少なくとも一種の元素を含む酸化物、BN、SiC及びAlN等が挙げられる。また後述するように、第2の保護膜62としてSi酸化物を用いることもでき、この場合は、後述しているように第1の保護膜61の材料としてSi酸化物よりエッチングされ易い材料を選択して行われる。

【0023】図2～図5のストライプ構造としては、特に限定されないが、好ましいストライプ構造としては、

例えばストライプ幅が $0.5 \sim 4.0 \mu\text{m}$ のストライプ構造をあげることができる。ストライプ幅が上記範囲であると、しきい値の低下や水平横モードの安定化の点で好ましい。また、ストライプ幅が上記のように狭い構造のストライプを有するレーザ素子としては、前記したように、例えば図2～図4に示されるような構造のレーザ素子が挙げられる。これらのレーザ素子は、ストライプ幅を狭くしても再現性良く形成することができるストライプ及び電極形成方法（具体的には特開平2000-4063号に開示されている。）により得られる。以下にその方法について図5を用いて説明する。この方法は、ストライプの導波路を形成する際に用いる第1の保護膜61と、ストライプの側面に形成される絶縁性の第2の保護膜62との、エッチング処理によるエッチング速度が異なるように材料を選択し、下記各工程を行うことにより、再現性よくストライプを形成でき、更に所定の位置に絶縁性の第2の保護膜62を均一の膜厚で形成することができる。

【0024】図5は、図2～図4の窒化物半導体レーザ素子のストライプ及び電極の形成方法の各工程を説明するための、各工程における窒化物半導体ウェーハの部分断面図を示す模式的断面図である。この図5に示される断面図は、エッチングにより形成したストライプ導波路に対し垂直方向、つまり共振面に対して平行方向で切断した際の図を示している。

【0025】まず、第1の工程において、図5(c)に示すように、最上層にあるp型コンタクト層13の上にストライプ状の第1の保護膜61を形成する。この第1の工程において、第1の保護膜61は、特に絶縁性は問わず、窒化物半導体のエッチング速度と差がある材料であればどのような材料でも良い。更に第1の保護膜61としては、後述の第3の工程で形成される第2の保護膜62とエッチング速度の異なる材料を選択して用いることが第2の保護膜62を形成するのに好ましい。第1の保護膜61として、例えばSi酸化物( $\text{SiO}_2$ を含む)、フォトレジスト等が挙げられ、好ましくはSi酸化物である。第1の保護膜61が、Si酸化物であると、次の第2の工程における窒化物半導体レーザ素子のストライプ状の導波路領域を形成する方法としてウェットエッチングやドライエッチング等が用いられるが、エッチングのし易いドライエッチングが好ましく用いられ、このドライエッチングで重要視される第1の保護膜61と窒化物半導体との選択性を良好にすることができる。また、第1の保護膜61が上記の材料から選択されると、後工程である第3の工程で酸を用いて行うエッチングで第2の保護膜よりも酸に対して溶解されやすい性質を有し、第2の保護膜62との溶解度差を設け易く、特に第3の工程で用いられる酸としてフッ酸を用いると、フッ酸に対して溶解しやすく好ましい。第1の保護膜のストライプ幅(W)としては $4 \mu\text{m} \sim 0.5 \mu\text{m}$ 、

好ましくは $3 \mu\text{m} \sim 1 \mu\text{m}$ に調整する。第1の保護膜61のストライプ幅が、おおそ導波路領域のストライプ幅に相当する。

【0026】第1の工程において、第1の保護膜61を形成する具体的な工程として、図5(a)、(b)に示す工程が挙げられる。まず、図5(a)に示すように、第1の保護膜61をp型コンタクト層13の表面のほぼ全面に形成した後、第1の保護膜61の上にストライプ状の第3の保護膜63を形成する。その後、図5(b)に示すように、その第3の保護膜63をつけたまま、第1の保護膜61をエッチングした後、第3の保護膜63を除去することにより、図5(c)に示すようなストライプ状の第1の保護膜61を形成することができる。なお第3の保護膜63をつけたままエッチングガス、若しくはエッチング手段等を変えて、p型コンタクト層13側からエッチングすることもできる。

【0027】第1の工程において、エッチング手段としては、例えばRIE（反応性イオンエッチング）のようなドライエッチングを用いることができ、この場合、第1の工程で例えばSi酸化物よりなる第1の保護膜61をエッチングするには、 $\text{CF}_4$ のようなフッ素化合物系のガスを用いることが望ましい。

【0028】また、図5(c)に示すようなストライプ状の第1の保護膜61をリフトオフ法によって形成することもできる。リフトオフ法では、ストライプ状の孔が開いた形状のフォトレジストをp型コンタクト層13上に形成し、そのフォトレジストの上から全面に第1の保護膜61を形成し、その後フォトレジストを溶解除去することにより、p型コンタクト層13と接触している第1の保護膜61のみを図5(c)に示すように残すものである。なお、第1の保護膜61を形成する方法としては、リフトオフ法でストライプ状の第1の保護膜61を形成するよりも、図5(a)、(b)のようにエッチングにより形成する方が端面がほぼ垂直で形状が整ったストライプが得られやすい傾向にある。

【0029】次に第2の工程において、図5(d)に示すように、第1の保護膜61が形成されたp型コンタクト層13の第1の保護膜61が形成されていない部分からエッチングして、第1の保護膜61の直下部分に保護膜の形状に応じたストライプ状の導波路領域を形成する。エッチングを行う場合、エッチストップをどの位置にするかでレーザ素子の構造、特性が異なってくる。エッチストップはp型コンタクト層よりも下の層であればどの窒化物半導体層で止めてもよい。図5に示す例ではp型コンタクト層13の下にあるp型クラッド層12の途中をエッチストップとしている。p型クラッド層の下端面からp型コンタクト層方向 $0.2 \mu\text{m}$ よりも基板側をエッチストップとすると、ストライプがリッジとなって屈折率導波路型のレーザ素子ができる。下端面とは厚さ方向に対して最も下のクラッド層の面を指し、先にも

述べたようにクラッド層の下に光ガイド層がある場合には、ガイド層とクラッド層の界面が下端面に相当する。エッチストップをこの下端面よりも上にとすると、エッチング時間が短くなり、またエッチングレートを制御しやすいので、生産技術上都合がよい。

【0030】また図5には示していないが、エッチストップをp型クラッド層の下端面よりも下にある窒化物半導体とすることもできる。下端面よりも基板側の層をエッチストップとすると、しきい値が著しく低下する傾向があり好ましい。

【0031】第2の工程において、エッチング手段としては、ウェットエッチングやドライエッチング等が用いられるが、エッチングのし易いドライエッチングが好ましく用いられる。例えばRIE（反応性イオンエッチング）のようなドライエッチングを用いることができ、この場合、窒化物半導体をエッチングするには他のIII-V族化合物半導体で良く用いられているCl<sub>2</sub>、CCl<sub>4</sub>、SiCl<sub>4</sub>のような塩素系のガスが用いられ、これらのガスを用いると、第1の保護膜61としてSi酸化物が用いられている場合、Si酸化物との選択比が大き

くできるため望ましい。

【0032】図5の(d)に示すようにエッチングしてリッジ形状のストライプを形成した後、リッチ層201を形成する。リッチ層201の形成の方法は前記したとおりである。図5(e-1)には、蒸着によりリッジ形状のストライプの側面及びその側面から連続している平面にAlなどの蒸着膜を形成した状態を示してある。このAlなどの蒸着膜を形成後、熱拡散によりAlなどの蒸着膜と接している素子構造の表面から内部に向かってAlなどの豊富な部分を形成する。その後、図5(e-2)に示すようにAlなどの蒸着膜を除去することでリッチ層201を形成することができる。

【0033】次にリッチ層201を形成した後、第3の工程において、図5(f)に示すように、第2の保護膜62を第1の保護膜61と異なる材料であって、絶縁性を有する材料を用いてストライプ状の導波路の側面、エッチングされて露出した窒化物半導体層（図5(f)では、p型クラッド層12）の平面、及び第1の保護膜61上に形成する。第2の保護膜62を形成後に、エッチングにより第1の保護膜61を除去することにより、第1の保護膜61上に形成された第2の保護膜62のみが除去され、図5(g)に示すように、ストライプの側面及びp型クラッド層12の平面には第2の保護膜62が連続して形成される。このように第2の保護膜62をエッチングすることなく、第1の保護膜61を除去することを可能にするには、前記したように、第1の保護膜61と第2の保護膜62の材料を、第3の工程で行われるエッチング処理に対するエッチング速度の異なるものを選択して用いることにより可能となる。第3の工程でのエッチング処理は、特に限定されないが、例えばフッ酸

を用いてドライエッチングする方法が挙げられる。

【0034】第2の保護膜62の材料としては、第1の保護膜61と異なる材料から選択され、第3の工程のエッチング処理で第1の保護膜61よりエッチング速度が遅い又はエッチングされにくい材料であって、ストライプの側面等に第2の保護膜62が形成可能な材料であれば特に限定されない。好ましい第2の保護膜としては、前記のように第1の保護膜61としてSi酸化物やレジスト材料が好ましく用いられることから、少なくとも第1の保護膜61の材料以外の材料で、第1の保護膜61よりエッチング速度が遅い材料が挙げられる。第1の保護膜61がSi酸化物である場合、第2の保護膜62の具体例としては、例えばTi、V、Zr、Nb、Hf、Taよりなる群から選択された少なくとも一種の元素を含む酸化物、BN、SiC及びAlNの内の少なくとも一種が用いられ、より好ましくはZrの酸化物、Hfの酸化物、BN及びSiCのいずれか一種以上の材料が用いられる。また、第2の保護膜62形成後、窒化物半導体をエッチングしないため、第2の保護膜62は、窒化物半導体とのエッチング速さに関して考慮されない。また第2の薄膜層62として、Si酸化物を用いてもよく、この場合は、第1の保護膜61をSi酸化物より第3の工程でのエッチング速度の速い材料が選択され行われる。

【0035】また、上記の如く、第1の保護膜61上に第2の保護膜を連続して形成することにより、高い絶縁性を保持でき、p型クラッド層12の上に均一な膜厚で形成できるため膜厚の不均一に起因する電流の集中の発生を防止できる。また、上記第2の工程において、エッチストップをp型クラッド層12の途中としているため、第3の工程で図5(f)に示すように、第2の保護膜62はp型クラッド層12の平面に形成されるが、エッチストップをp型クラッド層12よりも下にとすると、第2の保護膜はエッチストップした窒化物半導体層の平面に形成される。

【0036】また、第2の保護膜62は、リフトオフ法によって形成することもできる。例えば、第2の保護膜62が上記した具体例のいずれかであり、第1の保護膜61をSi酸化物とすると、第2の保護膜62は、フッ酸に対して、Si酸化物よりエッチング速度が遅い又はエッチングされにくいといったエッチング選択性を有している。このため、図5(f)に示すようにストライプ導波路の側面、そのストライプが形成されている平面（エッチストップ層）、及び第1の保護膜61の表面に連続して第2の保護膜を形成した後、リフトオフ法により第1の保護膜61のみを除去すると、図5(g)に示すような、平面に対して膜厚が均一な第2の保護膜62が形成される。

【0037】次に第4の工程において、図5(h)に示すように、第2の保護膜62とp型コンタクト層13の

上に、そのp型コンタクト層13と電気的に接続したp電極20を形成する。ここで、前記工程により既に第2の保護膜62が形成されているので、p電極を形成する際、ストライプ幅の狭いコンタクト層のみに形成するといった細かい操作の必要がなく、p電極を大面積で形成でき、操作性が良好となる。

【0038】また、本発明において、上記のような幅の狭いリッジ形状のストライプを有す得る場合、p電極上に形成されるpパッド電極としては、特に限定されないが、好ましくは、少なくともストライプ長さと同一の長さでp電極全面を覆って形成された金属を含む第1の薄膜層と、該第1の薄膜層上にストライプ長さより短い長さで形成された金属を含む第2の薄膜層とから形成され、または第1と第2の薄膜層との間に第3の薄膜層を形成してなると、pパッド電極の劈開性が向上し、p電極の剥離を防止するのに好ましい。例えば、後述の実施例で用いられている図2等に示されている第1の薄膜層31上に第2の薄膜層32を形成してなるpパッド電極101が挙げられる。

【0039】第1の薄膜層が、Ni、Ti、Cr、W及びPt等の一種以上であると、劈開性、接着性、さらに放熱性等の点で好ましい。また、第2の薄膜層が、Auからなると、熱伝導率がよく熱の放散が良好となり、さらにボンディングの際の接着性や衝撃の緩和等の点で好ましい。Auからなる第2の薄膜層は、劈開性が劣るが、ストライプ長さより短い形状であるので、第2の薄膜層の端面が劈開により形成される劈開面に一致しておらず、pパッド電極の劈開性に何ら影響を与えない。また、第1の薄膜層と第2の薄膜層との間に、Pt、W、TiN、Cr及びNi等の少なくとも1種以上の材料を含む第3の薄膜層を形成すると、第3の薄膜層がバリア層となり第2の薄膜層の金属が拡散するのを防止でき好ましい。このように第2の薄膜層の拡散を防止できると、抵抗の上昇及びしきい値の上昇が抑えられ、それによってレーザ素子内部での熱の発生が防止されて、寿命特性を向上させるのに好ましい。

【0040】本発明において、p及びn電極としては、種々の材料を適宜選択して用いることができ、例えば前記J. J. A. P. に記載されているオーミック接触を有する電極等が挙げられる。

【0041】また、n電極が基板裏面に形成される場合、基板裏面にベタにn電極を形成後裏面からスクライプスすると、n電極に阻まれて窒化物半導体までスクライプが達しない場合があり、この問題点を防止するために、ウエハの基板裏面にパターン形状のn電極を形成することによりスクライプし易くなり、劈開性が向上する。パターン形状としては、ウエハを劈開して得られる1チップの形状が得られやすいように、チップの大きさとほぼ同程度の形状、例えば400 $\mu$ m $\times$ 400 $\mu$ mの形状、であることが好ましい。つまりスクライプライン

上及び/または劈開面上にn電極が存在しないようにパターンをつけてn電極を形成する。更にメタライズ電極もn電極と同様のパターン形状でn電極上に形成されると、スクライプし易くなり劈開性が向上する。n電極としては、特に限定されないが、例えばTi-Al、W-Al-W-Auなどを用いることができる。メタライズ電極としてはTi-Pt-Au-(Au/Sn) [膜厚0.1 $\mu$ m-0.2 $\mu$ m-0.7 $\mu$ m-0.3 $\mu$ m]、Ti-Pt-Au-(Au/Si) [膜厚前記と同様]、Ti-Pt-Au-(Au/Ge) [膜厚前記と同様]、Ti-Pt-Au-In [膜厚前記と同様]、Au/Sn [膜厚0.3 $\mu$ m]、In [膜厚前記と同様]、Au/Si [膜厚前記と同様]、Au/Ge [膜厚前記と同様] 等を用いることができる。n電極が裏面にパターン形状に形成される場合のチップ化の方法としては、例えば、裏面のn電極パターン間を裏面からスクライプによりバー状サンプルを作製し、端面へ反射ミラー形成後裏面からスクライプによりチップ化を行うことができる。

【0042】また本発明のレーザ素子のその他の素子構造としては、特に限定されず、公知の種々の素子構造を用いることができる。本発明のレーザ素子の素子構造を成長させる基板としては、従来知られている、サファイア、スピネル等の異種基板、又は、異種基板の上にSiO<sub>2</sub>等の窒化物半導体が成長しないかまたは成長しにくい材料からなる保護膜を形成して、その上に選択的に横方向の成長(ラテラル成長)をさせて得られる窒化物半導体基板等が挙げられる。好ましくはラテラル成長させて得られる結晶欠陥の少ない窒化物半導体基板が好ましい。結晶欠陥の少ない窒化物半導体基板上に、素子構造を形成すると、素子を構成する窒化物半導体も結晶欠陥が少なくなり、素子内での発熱を抑えるのに好ましい。また、基板が窒化物半導体基板であると、劈開し易くなりp電極の剥がれ防止の点でも好ましい。ラテラル成長に用いられる保護膜は、前記ストライプを形成する際に用いた保護膜とは異なる作用を示す。

【0043】ラテラル成長を用いて得られる結晶欠陥の少ない窒化物半導体基板の成長方法としては、特に限定されずいずれの方法でもよいが、例えば、J. J. A. P. Vol. 37(1998)pp. L309-L312に記載の方法や、本出願人が先に出願した特開平11-191659号に開示されている窒化物半導体と異なる異種基板上に成長させた窒化物半導体表面に凹凸部を形成し、その凸部及び凹部の平面上にSiO<sub>2</sub>等の前記保護膜を形成した後、側面に露出した窒化物半導体より横方向の成長を行い、保護膜上部に互いに横方向に成長した窒化物半導体を繋げる方法等が挙げられる。また、ラテラル成長により得られる窒化物半導体基板は、素子構造を成長させる際に、異種基板を有する状態で行っても、異種基板を除去した状態で行ってもよい。

【0044】本発明のレーザ素子の共振面は、リッジ形状のストライプと垂直になるように、窒化物半導体の{11-00}面〔M面：六角柱状の結晶の側面に相当する面〕で劈開することにより、鏡面状の良好な共振面を形成することができる。窒化物半導体のM面での劈開については、例えば本出願人が先に出願した特開平9-232676号公報に詳細が記載されている。

【0045】

【実施例】以下の本発明の一実施の形態である窒化物半導体レーザ素子の実施例を示す。しかし本発明はこれに

限定されない。

【実施例1】図2は、本発明の一実施例に係るレーザ素子の構造を示す模式的な断面図であり、ストライプ導波路に垂直な方向で切断した際の図を示すものである。以下、この図を基に実施例1について説明する。

【0046】（下地層2）1インチφ、C面を主面とするサファイアよりなる異種基板1をMOVPE反応容器内にセットし、温度を500℃にして、トリメチルガリウム（TMG）、アンモニア（NH<sub>3</sub>）を用い、GaNよりなるバッファ層を200オングストロームの膜厚で成長させる。バッファ層成長後、温度を1050℃にして、同じくGaNよりなる下地層2を4μmの膜厚で成長させる。この下地層は保護膜を部分的に表面に形成して、次に窒化物半導体基板の選択成長を行うための下地層として作用する。

【0047】（保護膜3）下地層成長後、ウェーハを反応容器から取り出し、この下地層の表面に、ストライプ状のフォトリソマスクを形成し、PVD装置によりストライプ幅10μm、ストライプ間隔（窓部）2μmのSiO<sub>2</sub>よりなる保護膜3を形成する。

【0048】（窒化物半導体基板4）保護膜形成後、ウェーハを再度MOVPEの反応容器内にセットし、温度を1050℃にして、TMG、アンモニアを用い、アンドープGaNよりなる窒化物半導体基板4を20μmの膜厚で成長させる。この窒化物半導体基板は保護膜3上部において横方向に成長されたものであるため、結晶欠陥が10<sup>3</sup>個/cm<sup>2</sup>以下と下地層2に比較して2桁以上少なくなる。

【0049】（n型コンタクト層5）次に、アンモニアとTMG、不純物ガスとしてシランガスを用い、窒化物半導体基板1の上に、1050℃でSiを3×10<sup>19</sup>/cm<sup>3</sup>ドープしたGaNよりなるn型コンタクト層5を4μmの膜厚で成長させる。

【0050】（クラック防止層6）次に、TMG、TM（トリメチルインジウム）、アンモニアを用い、温度を800℃にしてIn<sub>0.05</sub>Ga<sub>0.95</sub>Nよりなるクラック防止層6を0.15μmの膜厚で成長させる。なお、このクラック防止層は省略可能である。

【0051】（n型クラッド層7）続いて、1050℃でTMA（トリメチルアルミニウム）、TMG、アンモ

ニアを用い、アンドープAl<sub>0.15</sub>Ga<sub>0.85</sub>Nよりなる層を25オングストロームの膜厚で成長させ、続いてTMAを止めて、シランガスを流し、Siを1×10<sup>19</sup>/cm<sup>3</sup>ドープしたn型GaNよりなる層を25オングストロームの膜厚で成長させる。それらの層を交互積層して超格子層を構成し、総膜厚1.2μmの超格子よりなるn型クラッド層7を成長させる。

【0052】（n型光ガイド層8）続いて、シランガスを止め、1050℃でアンドープGaNよりなるn型光ガイド層8を0.1μmの膜厚で成長させる。このn型光ガイド層8にn型不純物をドープしても良い。

【0053】（活性層9）次に、温度を800℃にして、SiドープIn<sub>0.05</sub>Ga<sub>0.95</sub>Nよりなる障壁層を100オングストロームの膜厚で成長させ、続いて同一温度で、アンドープIn<sub>0.2</sub>Ga<sub>0.8</sub>Nよりなる井戸層を40オングストロームの膜厚で成長させる。障壁層と井戸層とを2回交互に積層し、最後に障壁層で終わり、総膜厚380オングストロームの多重量子井戸構造（MQW）の活性層を成長させる。

【0054】（p型キャップ層10）次に、温度を1050℃に上げ、TMG、TMA、アンモニア、Cp<sub>2</sub>Mg（シクロペンタジエニルマグネシウム）を用い、p型光ガイド層11よりもバンドギャップエネルギーが大きい、Mgを1×10<sup>20</sup>/cm<sup>3</sup>ドープしたp型Al<sub>0.15</sub>Ga<sub>0.85</sub>Nよりなるp型キャップ層7を300オングストロームの膜厚で成長させる。

【0055】（p型光ガイド層11）続いてCp<sub>2</sub>Mg、TMAを止め、1050℃で、バンドギャップエネルギーがp型キャップ層10よりも小さい、アンドープGaNよりなるp型光ガイド層11を0.1μmの膜厚で成長させる。

【0056】（p型クラッド層12）続いて、1050℃でアンドープAl<sub>0.15</sub>Ga<sub>0.85</sub>Nよりなる層を25オングストロームの膜厚で成長させ、続いてCp<sub>2</sub>Mg、TMAを止め、アンドープGaNよりなる層を25オングストロームの膜厚で成長させ、総膜厚0.6μmの超格子層よりなるp型クラッド層12を成長させる。

【0057】（p型コンタクト層13）最後に、1050℃で、p型クラッド層9の上に、Mgを1×10<sup>20</sup>/cm<sup>3</sup>ドープしたp型GaNよりなるp型コンタクト層13を150オングストロームの膜厚で成長させる。

【0058】以上のようにして窒化物半導体を成長させたウェーハを反応容器から取り出し、最上層のp型コンタクト層の表面にSiO<sub>2</sub>よりなる保護膜を形成して、RIE（反応性イオンエッチング）を用いSiCl<sub>4</sub>ガスによりエッチングし、図2に示すように、n電極を形成すべきn型コンタクト層5の表面を露出させる。このように窒化物半導体を深くエッチングするには保護膜としてSiO<sub>2</sub>が最適である。

【0059】次に、図5（a）に示すように、最上層の



p型コンタクト層13のはば全面に、PVD装置により、Si酸化物(主として、 $\text{SiO}_2$ )よりなる第1の保護膜61を0.5 $\mu\text{m}$ の膜厚で形成した後、第1の保護膜61の上に所定の形状のマスクをかけ、フォトレジストよりなる第3の保護膜63を、ストライプ幅2 $\mu\text{m}$ 、厚さ1 $\mu\text{m}$ で形成する。

【0060】次に、図5(b)に示すように第3の保護膜63形成後、RIE(反応性イオンエッチング)装置により、 $\text{CF}_4$ ガスを用い、第3の保護膜63をマスクとして、前記第1の保護膜61をエッチングして、ストライプ状とする。その後エッチング液で処理してフォトレジストのみを除去することにより、図5(c)に示すようにp型コンタクト層13の上にストライプ幅2 $\mu\text{m}$ の第1の保護膜61が形成できる。

【0061】さらに、図5(d)に示すように、ストライプ状の第1の保護膜61形成後、再度RIEにより $\text{SiCl}_4$ ガスを用いて、p型コンタクト層13、およびp型クラッド層12をエッチングして、ストライプ状の導波路領域(この場合、リッジストライプ)を形成する。ストライプを形成する際、そのストライプの断面形状を図2に示すような順メサの形状とすると、横モードがシングルモードとなりやすく非常に好ましい。

【0062】リッジ形状のストライプを形成後に、p型コンタクト層13にリッジ層が形成されないように保護するための膜を付けた状態で、リッジ形状のストライプの側面及びその側面から連続している平面上にAlをPVD装置により蒸着して蒸着膜を形成する[図5(e-1)]。次にアニール炉において、所定の時間、熱をかけて熱処理を行う。その後、酸でAlの蒸着膜を除去する。このようにして図5(e-2)のようにリッジ層201が形成される。

【0063】リッジ層201を形成後、ウェーハをPVD装置に移送し、図5(f)に示すように、Zr酸化物(主として $\text{ZrO}_2$ )よりなる第2の保護膜62を、第1の保護膜61の上と、エッチングにより露出されたp型クラッド層12の上に0.5 $\mu\text{m}$ の膜厚で連続して形成する。

【0064】次に、ウェーハをフッ酸に浸漬し、図5(g)に示すように、第1の保護膜61をリフトオフ法により除去する。

【0065】次に図5(h)に示すように、p型コンタクト層13の上の第1の保護膜61が除去されて露出したそのp型コンタクト層の表面にNi/Auよりなるp電極20を形成する。但しp電極20は100 $\mu\text{m}$ のストライプ幅として、この図5(h)に示すように、第2の保護膜62の上に渡って形成する。

【0066】次に、p電極20上の全面に連続して、Tiからなる第1の薄膜層31を1000 $\text{\AA}$ の膜厚で形成し、更に図2に示すようにストライプの側面等にも第1の薄膜層31を形成する。この連続して

形成された第1の薄膜層31上に、後の工程で劈開により共振面を形成する際の劈開面に一致しない大きさ、つまり劈開面となる部分の上部を避けて、断続的にAuからなる第2の薄膜層32を8000 $\text{\AA}$ の膜厚で形成し、第1の薄膜層31及び第2の薄膜層32からなるpパッド電極101を形成する。

【0067】pパッド電極形成後、一番最初に露出させたn型コンタクト層5の表面にはTi/Alよりなるn電極21をストライプと平行な方向で形成し、その上にTi/Pt/Auよりなるnパッド電極を形成する。

【0068】以上のようにして、n電極とp電極及びpパッド電極とを形成したウェーハのサファイア基板を研磨して70 $\mu\text{m}$ とした後、ストライプ状の電極に垂直な方向で、基板側からバー状に劈開し、劈開面(11-00面、六角柱状の結晶の側面に相当する面=M面)に共振器を作製する。共振器面に $\text{SiO}_2$ と $\text{TiO}_2$ よりなる誘電体多層膜を形成し、最後にp電極に平行な方向で、バーを切断して図2に示すようなレーザ素子とする。なお共振器長は300~500 $\mu\text{m}$ とすることが望ましい。

【0069】このレーザ素子をヒートシンクに設置し、それぞれの電極をワイヤーボンディングして、室温でレーザ発振を試みたところ、発振波長400~420nm、閾値電流密度2.9kA/ $\text{cm}^2$ において室温で良好な連続発振を示す。さらに、絶縁性が良好となったことで、リーク電流やショートが防止でき、寿命特性の良好なレーザ素子を効率よく得ることができ、歩留まりが向上する。

【0070】[実施例2]実施例1において、Alからなるリッジ層201をイオン注入により形成する他は同様にしてレーザ素子を作製する。イオン注入の方法としては、p型コンタクト層13の最上面に保護膜を付けた状態で、イオン注入装置でウェーハ上面よりAlを所定のエネルギーに加速してウェーハに打ち込む。次に、イオン注入でダメージを受けた部分を熱処理をして再結晶化させる。得られたレーザ素子は、実施例1と同様に良好な素子特性を示し、さらに歩留まりも向上する。

【0071】[実施例3]図3は本発明の他の実施例に係るレーザ素子の構造を示す模式的な断面図であり、以下この図を元に実施例3について説明する。

【0072】(窒化物半導体基板40)実施例1において、下地層2の表面にストライプ状の保護膜3形成後、ウェーハを再度MOVPEの反応容器内にセットし、温度を1050℃にして、TMG、アンモニアを用い、アンドープGaNを5 $\mu\text{m}$ の膜厚で成長させる。その後、ウェーハをHVPE(ハイドライド気相成長法)装置に移送し、原料にGaメタル、HClガス、及びアンモニアを用い、アンドープGaNよりなる窒化物半導体基板40を200 $\mu\text{m}$ の膜厚で成長させる。このようにMOVPE法により保護膜3の上に窒化物半導体を成長させ

た後、HVPE法で100 $\mu$ m以上のGa<sub>0.9</sub>N<sub>0.1</sub>厚膜を成長させると結晶欠陥は実施例1に比較してもう一桁以上少なくなる。窒化物半導体基板40成長後、ウェーハを反応容器から取り出し、サファイア基板1、バッファ層2、保護膜3、アンドープGa<sub>0.9</sub>N<sub>0.1</sub>層を研磨により除去し、窒化物半導体基板40単体とする。

【0073】後は実施例1と同様にして、研磨側と反対側の窒化物半導体基板40の上にn型コンタクト層5～p型コンタクト層13までを積層する。

【0074】p型コンタクト層13成長後、実施例1と同様にして、ストライプ状の第1の保護膜61を形成した後、第2の工程において、エッチングストップをn型コンタクト層5の表面とする。後は実施例1と同様にして、Alからなるリッチ層201を形成した後で、ZrO<sub>2</sub>を主成分とする第2の保護膜62をストライプ導波路の側面、及びn型コンタクト層5の表面に形成した後、それぞれのコンタクト層に電極を形成する。次に、実施例1と同様にpパッド電極101を形成し、図3に示すような構造のレーザ素子とする。なお共振面を形成する場合、窒化物半導体基板の劈開面は実施例1と同じM面とする。得られたレーザ素子は実施例1に比較して、閾値電流密度は1.8kA/cm<sup>2</sup>にまで低下し、寿命は3倍以上向上し、さらに実施例1と同様に絶縁性の向上によりリーク電流及びショートが良好に防止でき、良好な寿命特性を有するレーザ素子を歩留まりよく作製することができる。

【0075】[実施例4] 図4は本発明の他の実施例に係るレーザ素子の構造を示す模式的な断面図であり、以下この図4を用いて実施例4について説明する。

【0076】実施例3において、窒化物半導体基板40を作製する際にHVPE装置において原料にシランガスを加え、Siを1 $\times$ 10<sup>18</sup>/cm<sup>3</sup>ドープしたGa<sub>0.9</sub>N<sub>0.1</sub>よりなる窒化物半導体基板50を200 $\mu$ mの膜厚で成長させる。なおSi濃度は1 $\times$ 10<sup>17</sup>/cm<sup>3</sup>～5 $\times$ 10<sup>19</sup>/cm<sup>3</sup>の範囲とすることが望ましい。窒化物半導体基板50成長後、実施例3と同様にしてサファイア基板1、バッファ層2、保護膜3、アンドープGa<sub>0.9</sub>N<sub>0.1</sub>層を研磨して除去し、窒化物半導体基板50単体とする。

【0077】次にこの窒化物半導体基板50の上に実施例1と同様にして、クラック防止層6～p型コンタクト層13までを積層成長させる。p型コンタクト層13成長後、実施例1と同様にして、ストライプ状の第1の保護膜61を形成した後、第2の工程において、エッチングストップを図5に示すn型クラッド層7の表面とする。後は実施例1と同様にして、リッチ層201を形成し、その後、ZrO<sub>2</sub>を主成分とする第2の保護膜62をストライプ導波路の側面と、n型クラッド層7の表面とに形成した後、その第2の保護膜を介してp電極20を形成する。

【0078】次に、p電極21上に、ストライプ長さ

同一の長さとなるようにTiからなる第1の薄膜層31を膜厚1000 $\text{\AA}$ で、第2の薄膜層32の形状と同様の形状でPtよりなる第3の薄膜層を膜厚1000 $\text{\AA}$ で、及びストライプ長さより短い形状でAuからなる第2の薄膜層32を膜厚800 $\text{\AA}$ で順に積層形成してなるpパッド電極101を図4に示すように形成する。第3の薄膜層は図示していないが、第2の薄膜層と同様の形状で形成する。一方、窒化物半導体基板の裏面側のほぼ全面にn電極21を形成する。電極形成後、窒化物半導体基板のM面で劈開して共振面を作製し、図4に示すような構造のレーザ素子とする。

【0079】[実施例5] 前記J. J. A. P. に記載されているレーザ素子を示す図6のレーザ素子に、図1に示すように、実施例1と同様にしてリッチ層201を形成してなるレーザ素子を作製する。得られたレーザ素子は、絶縁性が良好となりリーク電流の発生やショートが発生を防止でき、寿命特性の良好な素子を歩留まりよく作製することができる。

【0080】[実施例6] 実施例1において、Alに替えてBを用いる他は同様にして、拡散によりBを豊富に含有するリッチ層201を形成されてなるレーザ素子を作製する。その結果、実施例1とはほぼ同等の良好な結果が得られる。

【0081】[実施例7] 実施例2において、Alに替えてBを用いる他は同様にして、イオン注入によりBを豊富に含有するリッチ層201を形成されてなるレーザ素子を作製する。その結果、実施例1とはほぼ同等の良好な結果が得られる。

【0082】

【発明の効果】本発明の窒化物半導体レーザ素子は、上記のように素子構造のリッチ形状のストライプの側面及びその側面から連続している平面の表面付近にAl又はBを豊富に含有するリッチ層を形成することにより、絶縁膜（第2の保護膜を含む）とリッチ層とが相乗的に作用して良好な絶縁性を有するレーザ素子を作製することができる。そして、リーク電流の防止やショートを防止が防止でき寿命特性の良好なレーザ素子を歩留まりよく得ることができる。またさらに、本発明は、リッチ層の形成の状態により、光閉じこめを良好にすることができ、実効屈折率型の素子構造であっても、完全屈折率型の素子構造に変更することが可能となり、水平横モードの安定化やしきい値の低下の点で好ましいレーザ素子となる。

【図面の簡単な説明】

【図1】本発明の一実施の形態に係る窒化物半導体レーザ素子の一部分を示す模式的断面図である。

【図2】本発明の一実施の形態に係る窒化物半導体レーザ素子の模式的断面図である。

【図3】本発明の一実施の形態に係る窒化物半導体レー

ザ素子の模式的断面図である。

【図4】本発明の一実施の形態に係る窒化物半導体レーザ素子の模式的断面図である。

【図5】図2～図4のリッジ形状のストライプなどを形成する方法の各工程を説明するための、各工程におけるウェーハの部分的な構造を示す模式的断面図である。

【図6】従来のレーザ素子の構造を示す模式的断面図である。

【符号の説明】

1・・・異種基板

2・・・下地層

3・・・窒化物半導体基板成長用の保護膜

4、40、50・・・窒化物半導体基板

5・・・n型コンタクト層

6・・・クラック防止層

7・・・n型クラッド層

\* 8・・・n型光ガイド層

9・・・活性層

10・・・p型キャップ層

11・・・p型光ガイド層

12・・・p型クラッド層

13・・・p型コンタクト層

15・・・絶縁膜

61・・・第1の保護膜

62・・・第2の保護膜

10 63・・・第3の保護膜

20・・・p電極

21・・・n電極

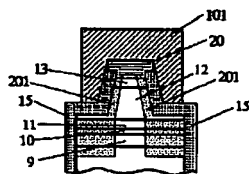
31・・・第1の薄膜層

32・・・第2の薄膜層

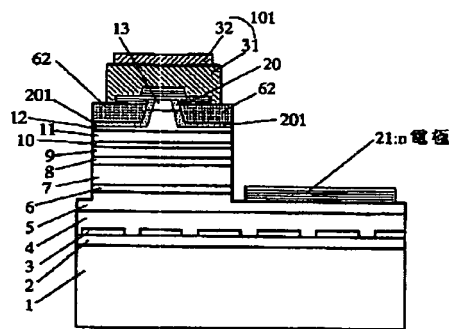
101・・・パッド電極

\* 201・・・リッジ層

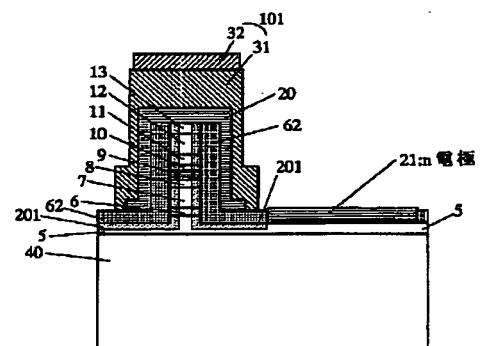
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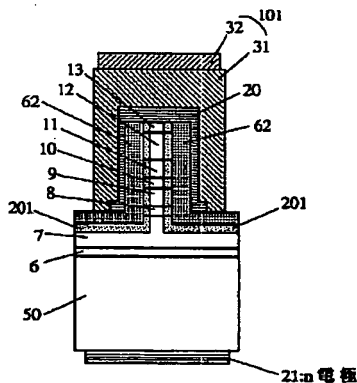
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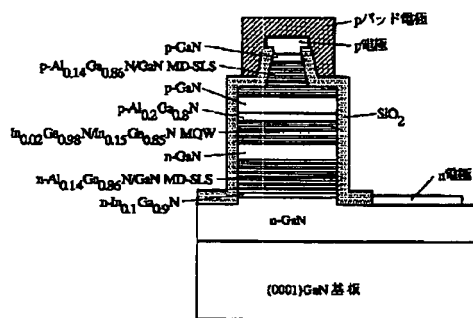
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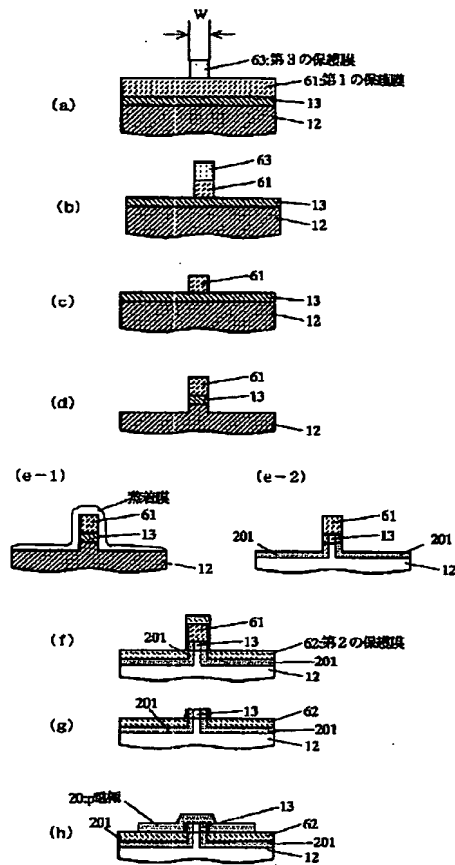
【図4】



【図6】



【図5】



フロントページの続き

F ターム(参考) 5F041 AA03 AA44 CA04 CA05 CA34  
 CA40 CA46 CA57 CA73  
 5F045 AA04 AB14 AB17 AB18 AB32  
 AC01 AC08 AC12 AD09 AD12  
 AD14 AF09 AF20 BB16 CA12  
 CB10 DA53 DA54 DA55 HA12  
 HA15 HA16  
 5F073 AA13 AA45 AA51 AA74 CA07  
 CB05 DA13 DA14 DA16 DA32  
 EA23 EA28

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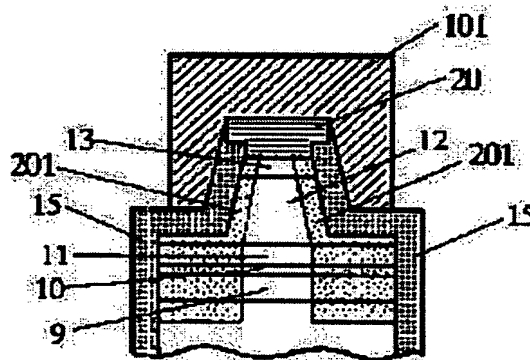
(22)Date of filing : 27.01.2000 (72)Inventor : MATSUMURA HIROAKI

## (54) NITRIDE SEMICONDUCTOR LASER ELEMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a nitride semiconductor laser element, where the insulating property of the element is improved, leakage current and short-circuiting are prevented and elements superior in service life characteristic can be obtained with high yield.

SOLUTION: This nitride semiconductor laser element has a structure, where an N-type nitride semiconductor layer, an active layer and a P-type nitride semiconductor layer are grown on a substrate. A ridge-shaped stripe is formed from the P-type nitride semiconductor layer side through etching, and an insulating film 15 is formed at least on the side surface of the ridge-shaped stripe. A rich layer 201, containing abundant aluminum or boron is formed at least on a side surface of the ridge-shaped stripe which is in contact with the insulation film 15 and in the vicinity of a plane surface which continues from the side surface of the stripe.



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**CLAIMS**

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[Claim(s)]

[Claim 1] It has the component structure of making n mold nitride semi-conductor layer, a barrier layer, and p mold nitride semi-conductor layer coming to grow up at least on a substrate. In the nitride semiconductor laser component which etching comes to form the stripe of a ridge configuration from p mold nitride semi-conductor layer side, and comes to form an insulator layer in the side face of the stripe of said ridge configuration further at least The nitride semiconductor laser component characterized by having the rich layer which contains aluminum or boron at abundance near the front face of the flat surface which is in contact with said insulator layer, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least.

[Claim 2] The nitride semiconductor laser component according to claim 1 characterized by coming to form said rich layer in the front face of the flat surface which is exposed, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least by diffusing aluminum or boron after forming the stripe of a ridge configuration.

[Claim 3] The nitride semiconductor laser component according to claim 1 characterized by said rich layer carrying out the ion implantation of aluminum or the boron to the front face of the flat surface which is exposed, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least, and coming to form it in it after forming the stripe of a ridge configuration.

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[Translation done.]

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**DETAILED DESCRIPTION**

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**[Detailed Description of the Invention]****[0001]**

[Industrial Application] Especially insulation of this invention is good about the laser component which consists of a nitride semi-conductor ( $\text{In}_a\text{Al}_b\text{Ga}_{1-a-b}\text{N}$ ,  $0 \leq a$ ,  $0 \leq b$ ,  $a+b \leq 1$ ), and it is related with the long nitride semiconductor laser component of the life from which leakage current and a short circuit were prevented.

**[0002]**

[Description of the Prior Art] In recent years, many researches and developments are done for utilization of a nitride semiconductor laser component, and various nitride semiconductor laser components are known. this invention person etc. as a usable laser component for example, to Jpn.J.Appl.Phys.Vol.37(1998) pp.L309-L312, Part2, No.3B, and 15 March 1998 20 micrometers (Epitaxially laterally overgrown GaN) of ELOG(s) are formed in the silicon-on-sapphire upper part. After growing up GaN after that until thickness is set to 100 micrometers, the GaN substrate with which about 80-micrometer rearrangement was reduced was obtained by deleting silicon on sapphire, and the nitride semiconductor laser component which comes to carry out two or more laminatings of the nitride semiconductor layer which serves as laser component structure on this GaN substrate is announced. And this laser component announced the nitride semiconductor laser component which makes possible 10,000 hours or more of continuous oscillation in a room temperature. The same typical sectional view as the laser component shown in drawing 6 at above-mentioned J.J.A.P. was shown. As shown in this drawing 6, it has the stripe of the ridge configuration which etched selectively and was formed to p mold cladding layer which consists of a p mold contact layer which consists of p-GaN from the superstructure of p-aluminum<sub>0.14</sub>Ga<sub>0.86</sub>N/GaN. It is the nitride semiconductor laser component which the insulator layer which benefits the insulation of a component from SiO<sub>2</sub> is formed in the side face of the stripe of the formed ridge configuration, and p electrode is further formed in said stripe upper part, and comes to form a resonance side by cleavage. Furthermore, p pad electrode is formed so that this laser component may cover p electrode. Thus, by forming the insulator layer in the side face of the stripe of a ridge configuration, prevention of a short circuit and prevention of leakage current are performed.



[0003]

[Problem(s) to be Solved by the Invention] However, in the obtained laser component, in spite of being the laser component formed on the same conditions, what has an extremely bad life property arises. As a result of examining many things about the cause that a life property falls extremely, since the insulation of the insulator layer of the side face of the stripe of a ridge configuration was imperfect, leakage current arose and this invention person surmised that it was for a short circuit to occur. To both attain improvement in the yield as if for \*\* which suited commercializing a laser component to make component properties, such as a life property, good is desired.

[0004] Then, the object of this invention is offering the nitride semiconductor laser component which can make the insulation of a component good, can prevent prevention and a short circuit of leakage current, and can obtain a component with a good life property with the sufficient yield.

[0005]

[Means for Solving the Problem] That is, the configuration of following the (1) - (3) can attain the object of this invention.

(1) It has the component structure of making n mold nitride semi-conductor layer, a barrier layer, and p mold nitride semi-conductor layer coming to grow up at least on a substrate. In the nitride semiconductor laser component which etching comes to form the stripe of a ridge configuration from p mold nitride semi-conductor layer side, and comes to form an insulator layer in the side face of the stripe of said ridge configuration further at least The nitride semiconductor laser component characterized by having the rich layer which contains aluminum or boron at abundance near the front face of the flat surface which is in contact with said insulator layer, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least.

(2) A nitride semiconductor laser component given in the above (1) characterized by coming to form said rich layer in the front face of the flat surface which is exposed, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least by diffusing aluminum or boron after forming the stripe of a ridge configuration.

(3) A nitride semiconductor laser component given in the above (1) characterized by said rich layer carrying out the ion implantation of aluminum or the boron to the front face of the flat surface which is exposed, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least, and coming to form it in it after forming the stripe of a ridge configuration.

[0006] That is, by forming the rich layer which make abundance come to contain aluminum or boron toward the interior near [ , such as a side face of the stripe of a ridge configuration , ] a front face from a front face , this invention act in multiplication with the insulator layer form in the side face of the stripe of a ridge configuration , and the good insulation of it be attain , and it can offer the nitride semiconductor laser component which become possible [ preventing leakage current and a short circuit good ] . Furthermore, this invention can also attain improvement in the yield by considering as the laser component which has a rich layer.

[0007] Conventionally, as shown in drawing 6, the insulating insulator layer is formed in the side face of the stripe of a ridge configuration. However, the case where this insulator layer is not uniform good film will arise, insulation will become imperfect, and a short circuit etc. will occur.

[0008] On the other hand, the result examined variously that this invention person should make the insulation of the part which touches a pad electrode a much more perfect thing, Make aluminum (aluminum) or boron (B) contain near the front face of the flat surface which is continuing from the side face of a stripe, and the side face of a stripe in abundance, and a rich layer is formed. By making into insulation the front face of the component structure exposed by forming the stripe of a ridge configuration itself, a rich layer and an insulator layer can act in multiplication, and can have good insulation.

[0009] furthermore, the thing make for front faces, such as a side face of the stripe of a ridge configuration expose, to diffuse aluminum or boron after a rich layer forming the stripe of a ridge configuration in this invention -- or when it come to be form by carrying out the ion implantation of aluminum or the boron, while being able to form a rich layer good and showing better insulation, it be desirable in respect of improvement in the yield.

[0010] Moreover, in this invention, when an ion implantation is carried out, the refractive index of the part is desirable in aluminum or B, also at diffusion or the point which becomes small and light shuts up. From this, although the laser component of drawing 6 is an effective-index waveguide mold since p electrode has not touched all over the front face of p mold contact layer, for example An ion implantation is spread or carried out. aluminum or B to the side face of a barrier layer 9 for the laser component of drawing 6, as shown in drawing 1 By forming the rich layer 201, it becomes a perfect refractive-index waveguide mold because slight optical closing depth becomes good, and the level transverse mode can be stable, lifting of a threshold can be prevented, a life property can be raised, and it is desirable.

[0011]

[Embodiment of the Invention] Drawing 1 - drawing 4 are used for below, and this invention is further explained to it at a detail. Drawing 1 is the typical sectional view showing the part cut at right angles to the die-length direction of the stripe of the ridge configuration of the nitride semiconductor laser component which is the gestalt of the 1 operation which comes to form the rich layer 201 of this invention in the laser component of drawing 6 shown with said conventional technique. Drawing 2 - drawing 4 are the typical sectional views of the nitride semiconductor laser component which is the gestalt of the 1 operation which comes to form the rich layer 201 of this invention in the laser component used as a perfect refractive-index waveguide mold.

[0012] The nitride semiconductor laser component of this invention has the rich layer which contains aluminum or boron at abundance near the front face of the flat surface which is in contact with the insulator layer, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least in the nitride semiconductor laser component which comes to form an insulator layer in the side face of the stripe of a ridge configuration. Therefore,

especially as a laser component which forms a rich layer, it is not limited but, specifically, the laser component of drawing 1 - drawing 4 is mentioned that what is necessary is just the laser component which has the stripe of a ridge configuration.

[0013] First, the rich layer 201 is explained using drawing 1. An insulator layer is formed in the side face of the stripe of a ridge configuration at drawing 1, the p electrode 20 is formed in the maximum upper layer of a stripe, and p pad electrode is formed in the upper part part of a stripe so that p electrode and an electric target may be contacted. And the rich layer 201 is formed near the front face of the flat surface which is continuing from the side face of the stripe of a ridge configuration in which the insulator layer 62 is in contact with component structure, and the side face of a stripe. after protect formation of the rich layer 201 in the case of this drawing 1 so that the rich layer 201 may not be form in the maximum top face ( front face of p mold contact layer ) of p mold nitride semiconductor layer, after form the stripe of a ridge configuration, it be make to contain near the front face which be have aluminum or B expose by diffusion and the ion implantation in abundance in the process of formation of the conventional component.

[0014] In this invention, near a front face shows the part which has the depth toward the inside from the front face of the exposed component structure, after forming the stripe of a ridge configuration. For example, the part in which the rich layer 201 shown in drawing 1 -4 is formed is shown. Moreover, in this invention, though it is the same layer as containing in abundance like p mold contact layer of drawing 2, and p mold cladding layer, more aluminum or B than other parts are contained, and the condition that aluminum and B are unevenly distributed is shown. And the part in which aluminum and B are unevenly distributed is used as the rich layer 201 by this invention.

[0015] In this invention, after formation of the rich layer 201 forms the stripe of a ridge configuration, it is formed in the exposed part by making aluminum or B contain near the front face of the part where especially p pad electrode is formed in an upper part part at abundance. Especially as an approach of making abundance containing aluminum and B, although not limited, after making a part to form a rich layer in vapor-deposit aluminum and B, in this invention, the method of applying and diffusing heat or the approach by the ion implantation is mentioned, for example as a desirable example.

[0016] In this invention, it heat-treats by making the part to diffuse vapor-deposit aluminum or B as an approach of diffusing. As temperature in the case of heat treatment, it is adjusted suitably, for example, is 400 degrees C - 700 degrees C. As time amount of heat treatment, it is adjusted suitably, for example, is 10 minutes - 2 hours. Moreover, when forming the rich layer 201 by diffusion, adjustment of concentration and accommodation of the depth from a front face are performed by adjusting the temperature and time amount of heat treatment.

[0017] aluminum or B which the mask of the part to make it pouring in was carried out [ B ], and made it ionize all over a wafer by Si oxide film or the resist as an approach of carrying out an ion implantation in this invention -- 10- it is carried out by accelerating to the energy of hundreds keV(s) and devoting oneself to a

front face. Moreover, when forming the rich layer 201 by the ion implantation, adjustment of concentration and accommodation of the depth from a front face are performed by adjusting impregnation time amount in acceleration voltage. [0018] Moreover, it is extent which is limited and can take \*\*\*\* and insulation especially as aluminum of the rich layer 201, or concentration of B, for example, they are specifically three or more  $1 \times 10^{14}$  atom/cm. Moreover, although especially the thickness (depth from a front face) of the rich layer 201 is not limited, it is extent which can take insulation, for example, is specifically 100Å – 2 micrometers.

[0019] for example, as a gestalt of 1 implementation of formation of the ridge layer 201 On a substrate as indicated by J.J.A.P. shown with said conventional technique n mold contact layer, From p mold nitride semi-conductor layer side after forming the component structure of making a barrier layer, p mold contact layer, etc. coming to grow up, by etching etc. After forming the stripe of a ridge configuration, Where a rich layer is made not to be formed in the front face of the maximum upper layer of the stripe of a ridge configuration, (in for example, the condition that protective coats, such as a resist formed on the occasion of etching, are formed) The ridge layer 201 is formed at least by the diffusion and the ion implantation which are exposed and which were shown in the side face of the stripe of a ridge configuration etc. above. Then, an insulator layer 15, the p electrode 20, and p pad electrode 101 grade are formed like said J.J.A.P. etc. And it becomes the laser component which has the rich layer 201 shown in drawing 1. Especially as an insulator layer 62 of drawing 1, although not limited, SiO<sub>2</sub> grade can be used. Moreover, especially as a stripe of the ridge configuration of drawing 1, although not limited, the content indicated by J.J.A.P. shown above, for example and the same content are mentioned.

[0020] By forming the rich layer 201, the rich layer 201 and an insulator layer 15 act in multiplication, insulation becomes good, and the laser component shown in drawing 1 can perform prevention of leakage current, and prevention of a short circuit, and turns into a laser component with a good life property. In case the laser component furthermore shown in drawing 1 can be produced with the sufficient yield and mass-produced, it is desirable. Since insulation becomes good [ the laser component of this invention ], furthermore, the desirable laser component shown in drawing 1 again also in respect of the improvement in the dependability of a component (defect prevention) Although nonuniformity arises in current density inside the stripe of a ridge configuration, the level transverse mode becomes unstable and lifting of a threshold may be seen in the condition of not forming the rich layer 201 since p electrode has not touched all over the front face of p mold contact layer A component property like the laser component of a perfect refractive-index waveguide mold becomes easy to be shown by the refractive index of the part becoming small by making aluminum or B contain, and slight optical closing depth becoming good. Thus, if lifting of a threshold is suppressed, a life property can be made more into fitness. The rich layer 201 shown in drawing 1 can adjust thickness by adjusting suitably according to the diffusion at the time of forming the rich layer 201, or the conditions of an ion implantation, although horizontal thickness differs from vertical thickness to a

substrate. The thickness of a rich layer shows whether aluminum or B has entered to the depth of how much in component structure here.

[0021] Next, the laser component of drawing 2 - drawing 4 is explained. By the whole surface surface of p mold contact layer having touched p electrode, since stripe width of face is narrow, the level transverse mode stabilizes drawing 2 - drawing 4, since they can suppress lifting of a threshold, they are desirable, and they serve as still more desirable structure as a laser component of a perfect refractive-index waveguide mold. Laminating growth of n mold contact layer 5 - the p mold contact layer 13 is carried out on a substrate at drawing 2 - drawing 5. The stripe of a ridge configuration is formed by etching from this p mold contact layer side. As the 2nd protective coat 62 (insulating film equivalent to the insulator layer of this invention) is formed in the side face of the stripe of a ridge configuration and p mold contact layer which is the maximum upper layer of a stripe is touched, they are p electrode and the laser component which p pad electrode is formed and becomes so that p electrode may be touched further. Here, although the 2nd protective coat 62 is formed in order to be the insulating film, to be equivalent to the insulator layer of this invention and to maintain the insulation of a component like the insulator layer 15 of drawing 1, it is faced explaining the phase of formation of drawing 2 - drawing 5, and let it be the 2nd protective coat 62. And the rich layer 201 of this invention is formed in the flat surface which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe as shown in each drawing at such drawing 2 - drawing 5. By forming the rich layer 201, insulation is shown, it acts in multiplication with the 2nd insulating protective coat 62 currently formed in the side face of a stripe, and the part of the rich layer 201 also makes the insulation of a component good. Prevention of leakage current and prevention of a short circuit become good, and the improvement in a life property and improvement in the yield can be attained because insulation becomes good.

[0022] Especially as the 2nd protective coat 62 used as the insulator layer used for drawing 2 - drawing 5, although not limited, the oxide which contains at least a kind of element chosen from the group which consists of Ti, V, Zr, Nb, Hf, and Ta, BN, SiC, AlN, etc. are mentioned, for example. Moreover, Si oxide can also be used as the 2nd protective coat 62, and it is carried out by choosing the ingredient which is easy to be etched from Si oxide as an ingredient of the 1st protective coat 61 in this case as mentioned later as mentioned later.

[0023] Especially as stripe geometry of drawing 2 - drawing 5, although not limited, as desirable stripe geometry, the stripe geometry whose stripe width of face is 0.5-4.0 micrometers, for example can be raised. Stripe width of face is desirable in respect of the lowering of a threshold and the stabilization of the level transverse mode by it being the above-mentioned range. Moreover, as stripe width of face described above as a laser component which has the stripe of structure narrow as mentioned above, the laser component of structure as shown in drawing 2 - drawing 4 is mentioned. Even if these laser components narrow stripe width of face, they are obtained by the stripe and the electrode formation approach (specifically indicated by JP,2000-4063,A.) of forming with sufficient repeatability. Drawing 5 is used and explained about the approach below. By choosing an

ingredient so that the etch rates by etching processing with the 1st protective coat 61 used in case the waveguide of a stripe is formed, and the 2nd insulating protective coat 62 formed in the side face of a stripe may differ, and performing following each process, this approach can form a stripe with sufficient repeatability, and can form the 2nd insulating protective coat 62 in a position by the thickness of homogeneity further.

[0024] Drawing 5 is the typical sectional view showing the partial structure of the nitride semiconductor wafer in each process for explaining each process of the stripe of the nitride semiconductor laser component of drawing 2 - drawing 4, and the formation approach of an electrode. The sectional view shown in this drawing 5 shows drawing at the time of it being parallel and cutting to a perpendicular direction, i.e., a resonance side, to the stripe waveguide formed by etching.

[0025] First, in the 1st process, as shown in drawing 5 (c), the stripe-like 1st protective coat 61 is formed on p mold contact layer 13 in the maximum upper layer. In this 1st process, as long as the 1st protective coat 61 is an ingredient which does not ask especially insulation but has the etch rate and difference of a nitride semi-conductor, what kind of ingredient is sufficient as it. As the 1st protective coat 61, although choosing and using the ingredient with which the 2nd protective coat 62 formed at the 3rd below-mentioned process differs from an etch rate forms the 2nd protective coat 62, it is still more desirable. As the 1st protective coat 61, for example, Si oxide ( $\text{SiO}_2$  is included), a photoresist, etc. are mentioned, and it is Si oxide preferably. Although wet etching, dry etching, etc. are used as an approach it will form the waveguide field of the shape of a stripe of the nitride semiconductor laser component in the 2nd following process if the 1st protective coat 61 is Si oxide, the dry etching which etching tends to carry out is used preferably, and can make good selectivity of the 1st protective coat 61 and nitride semi-conductor to which importance is attached by this dry etching.

Moreover, it is easy to dissolve to fluoric acid and is desirable when fluoric acid is used as an acid which has the property which is easy to dissolve rather than the 2nd protective coat by etching which will be performed using an acid at the 3rd process which is an after process if the 1st protective coat 61 is chosen from the above-mentioned ingredient to an acid, is easy to establish a solubility difference with the 2nd protective coat 62, and is used especially at the 3rd process. As stripe width of face (W) of the 1st protective coat, 4 micrometers - 0.5 micrometers are preferably adjusted to 3 micrometers - 1 micrometer. The stripe width of face of the 1st protective coat 61 is about equivalent to the stripe width of face of a waveguide field.

[0026] In the 1st process, the process shown in drawing 5 (a) and (b) is mentioned as a concrete process which forms the 1st protective coat 61. First, as shown in drawing 5 (a), after [ the front face of p mold contact layer 13 ] forming in the whole surface mostly, the stripe-like 3rd protective coat 63 is formed for the 1st protective coat 61 on the 1st protective coat 61. Then, as shown in drawing 5 (b), after etching the 1st protective coat 61, with the 3rd protective coat 63 attached, the 1st protective coat 61 of the shape of a stripe as shown in drawing 5 (c) can be formed by removing the 3rd protective coat 63. In addition, etching gas or an etching means can be changed with the 3rd protective coat 63 attached, and it can

also etch from p mold contact layer 13 side.

[0027] In the 1st process, in order to be able to use dry etching like RIE (reactive ion etching), for example and to etch the 1st protective coat 61 which consists of Si oxide at the 1st process in this case as an etching means, it is desirable to use the gas of a fluorine compound system like CF<sub>4</sub>.

[0028] Moreover, the 1st protective coat 61 of the shape of a stripe as shown in drawing 5 (c) can also be formed by the lift-off method. By the lift-off method, by forming the photoresist of the configuration which the stripe-like hole opened on p mold contact layer 13, forming the 1st protective coat 61 the whole surface from the photoresist, and carrying out dissolution clearance of the photoresist after that, as shown in drawing 5 (c), it leaves only the 1st protective coat 61 in contact with p mold contact layer 13. In addition, as an approach of forming the 1st protective coat 61, it is in the inclination for the stripe with which an end face is [ to form by etching, as shown in drawing 5 (a) and (b) ] almost more nearly vertical, and the configuration was ready to be easy to be obtained rather than it forms the stripe-like 1st protective coat 61 by the lift-off method.

[0029] Next, in the 2nd process, as shown in drawing 5 (d), it etches from the part in which the 1st protective coat 61 of p mold contact layer 13 in which the 1st protective coat 61 was formed is not formed, and the waveguide field of the shape of a stripe according to the configuration of a protective coat is formed in a part for the direct lower part of the 1st protective coat 61. When etching, the structure of a laser component differs from a property by into which location a dirty stop is made. As long as a dirty stop is a layer below p mold contact layer, it may be stopped in any nitride semi-conductor layer. In the example shown in drawing 5, the middle of p mold cladding layer 12 under p mold contact layer 13 is considered as the dirty stop. If a substrate side is a dirty stop from the soffit side of p mold cladding layer rather than the 0.2 micrometers of the directions of p mold contact layer, a stripe will serve as a ridge and the laser component of a refractive-index waveguide mold will be made. A soffit side points out the field of the bottom cladding layer to the thickness direction, and as stated also in advance, when a lightguide layer is under a cladding layer, the interface of a guide layer and a cladding layer is equivalent to a soffit side. If a dirty stop is carried out above this soffit side, since etching time will become short and it will be easy to control an etching rate, convenience on industrial engineering is good.

[0030] Moreover, a dirty stop can also be used as the nitride semi-conductor below the soffit side of p mold cladding layer although not shown in drawing 5. When the layer by the side of a substrate is a dirty stop, it is [ an inclination for a threshold to fall remarkably ] and is more desirable than a soffit side.

[0031] In the 2nd process, as an etching means, although wet etching, dry etching, etc. are used, the dry etching which etching tends to carry out is used preferably. For example, if dry etching like RIE (reactive ion etching) can be used, the gas of a chlorine system like Cl<sub>2</sub>, CCl<sub>4</sub>, and SiCl<sub>4</sub> used well at other groups III-V semiconductor to etch a nitride semi-conductor in this case is used and these gas is used, when Si oxide is used as the 1st protective coat 61, since a selection ratio with Si oxide is made greatly, it is desirable.

[0032] After etching as shown in (d) of drawing 5, and forming the stripe of a ridge

configuration, the rich layer 201 is formed. The approach of formation of the rich layer 201 is as having described above. The condition of having formed vacuum evaporatio~~no~~ film, such as aluminum, in the flat surface which is continuing from the side face of the stripe of a ridge configuration and its side face by vacuum evaporatio~~no~~ is shown in drawing 5 (e-1). Abundant parts, such as aluminum, are formed toward the interior after forming vacuum evaporatio~~no~~ film, such as this aluminum, from the front face of the component structure which is in contact with vacuum evaporatio~~no~~ film, such as aluminum, with thermal diffusion. Then, the rich layer 201 can be formed by removing vacuum evaporatio~~no~~ film, such as aluminum, as shown in drawing 5 (e-2).

[0033] Next, in the 3rd process, after forming the rich layer 201, as shown in drawing 5 (f), it is an ingredient which is different from the 1st protective coat 61 in the 2nd protective coat 62, and forms using the ingredient which has insulation on the side face of stripe-like waveguide, the flat surface of the nitride semi-conductor layer ( drawing 5 (f) p mold cladding layer 12) which it was etched and was exposed, and the 1st protective coat 61. After forming the 2nd protective coat 62, by removing the 1st protective coat 61 by etching, only the 2nd protective coat 62 formed on the 1st protective coat 61 is removed, and as shown in drawing 5 (g), the 2nd protective coat 62 is continuously formed in the side face of a stripe, and the flat surface of p mold cladding layer 12. Thus, in order to make it possible to remove the 1st protective coat 61, without etching the 2nd protective coat 62, as described above, it becomes possible by choosing and using that from which the etch rate to the etching processing performed at the 3rd process differs the ingredient of the 1st protective coat 61 and the 2nd protective coat 62. Although especially etching processing at the 3rd process is not limited, the approach of carrying out dry etching, for example using fluoric acid is mentioned.

[0034] It is chosen from a different ingredient from the 1st protective coat 61 as an ingredient of the 2nd protective coat 62, and it will not be limited, especially if it is the ingredient which is hard to be etched by etching processing of the 3rd process or an etch rate is slower than the 1st protective coat 61 and is the ingredient which can form the 2nd protective coat 62 in the side face of a stripe etc. As the 2nd desirable protective coat, from Si oxide and a resist ingredient being preferably used as the 1st protective coat 61 as mentioned above, it is ingredients other than the ingredient of the 1st protective coat 61 at least, and an ingredient with an etch rate slower than the 1st protective coat 61 is mentioned. When the 1st protective coat 61 is Si oxide, a kind is used for inside [ it is the oxide which contains at least a kind of element chosen from the group which consists of Ti V, Zr, Nb, Hf, and Ta, for example as an example of the 2nd protective coat 62, and BN, SiC and AlN ] at least, and the oxide of Zr, the oxide of Hf, and any one or more sorts of ingredients of BN and SiC are used more preferably. Moreover, after the 2nd protective coat 62 formation, in order not to etch a nitride semi-conductor, the 2nd protective coat 62 is not taken into consideration about etching speed with a nitride semi-conductor. Moreover, as 2nd thin film layer 62, Si oxide may be used and the 1st protective coat 61 is performed in this case by choosing an ingredient with the etch rate quicker than Si oxide in the 3rd process.



[0035] Moreover, like the above, by continuing and forming the 2nd protective coat on the 1st protective coat 61, high insulation can be held, and since it can form by uniform thickness on p mold cladding layer 12, generating of concentration of the current resulting from the ununiformity of thickness can be prevented. Moreover, in the 2nd process of the above, since the dirty stop is considered as the middle of p mold cladding layer 12, as the 3rd process shows to drawing 5 (f), the 2nd protective coat 62 is formed in the flat surface of p mold cladding layer 12, but if a dirty stop is carried out below p mold cladding layer 12, the 2nd protective coat will be formed in the flat surface of the nitride semi-conductor layer which carried out the dirty stop.

[0036] Moreover, the 2nd protective coat 62 can also be formed by the lift-off method. For example, it is either of the examples which the 2nd protective coat 62 described above, and if the 1st protective coat 61 is used as Si oxide, the 2nd protective coat 62 has the etch selectivity of being hard to be etched or an etch rate is slower than Si oxide, to fluoric acid. For this reason, if only the 1st protective coat 61 is removed by the lift-off method after forming the 2nd protective coat succeeding the side face of stripe waveguide, the flat surface (dirty stop layer) in which that stripe is formed, and the front face of the 1st protective coat 61, as shown in drawing 5 (f), the 2nd protective coat 62 with uniform thickness will be formed to a flat surface as shown in drawing 5 (g).

[0037] Next, in the 4th process, as shown in drawing 5 (h), the p electrode 20 electrically connected with the p mold contact layer 13 is formed on the 2nd protective coat 62 and p mold contact layer 13. Here, since the 2nd protective coat 62 is already formed of said process, in case p electrode is formed, there is no need for fine actuation of forming only in the narrow contact layer of stripe width of face, p electrode can be formed by the large area and operability becomes good.

[0038] moreover, in this invention, when it may have the stripe of the ridge configuration where the above width of face is narrow, as a p pad electrode formed on p electrode The 1st thin film layer which contains the metal which covered whole p electrode surface and was formed by the same die length as stripe die length desirable at least although not limited especially, this — when it is formed from the 2nd thin film layer containing the metal formed by die length shorter than stripe die length on the 1st thin film layer or comes to form the 3rd thin film layer between the 1st and the 2nd thin film layer, it is desirable, although the cleavability of p pad electrode improves and exfoliation of p electrode is prevented. For example, p pad electrode 101 which comes to form the 2nd thin film layer 32 on the 1st thin film layer 31 shown in drawing 2 used in the below-mentioned example is mentioned.

[0039] The 1st thin film layer is desirable in respect of heat dissipation nature etc. to cleavability, an adhesive property, and a pan in their being more than kinds, such as nickel, Ti, Cr, W, and Pt. Moreover, when the 2nd thin film layer consists of Au, the heat conductivity becomes it is good and good [stripping of heat], and it is still more desirable in respect of the adhesive property in the case of bonding, relaxation of an impact, etc. Although the 2nd thin film layer which consists of Au is inferior in cleavability, since it is a configuration shorter than stripe die length,

the end face of the 2nd thin film layer is not in agreement with the cleavage plane formed of cleavage, and does not affect the cleavability of p pad electrode at all. Moreover, when the 3rd thin film layer containing at least one or more sorts of ingredients, such as Pt, W, TiN, Cr, and nickel, is formed between the 1st thin film layer and the 2nd thin film layer, it can prevent that the 3rd thin film layer turns into a barrier layer, and the metal of the 2nd thin film layer is spread, and is desirable. Thus, when diffusion of the 2nd thin film layer can be prevented, it is desirable for lifting of resistance and lifting of a threshold being suppressed, and generating of the heat inside a laser component being prevented by it, and raising a life property.

[0040] In this invention, the electrode which has the ohmic contact which can choose various ingredients suitably, and can use them as p and an n electrode, for example, is indicated by said J.J.A.P. is mentioned.

[0041] Moreover, in order to be obstructed by n electrode, and for a scribe not to attain even a nitride semi-conductor and to prevent this trouble if SUKURAIBUSU [ a substrate rear face / solid one / n electrode ] from an after [ formation ] rear face when n electrode is formed in a substrate rear face, by forming n electrode of a pattern configuration in the substrate rear face of a wafer, it becomes easy to carry out a scribe and cleavability improves. the configuration of one chip obtained by carrying out cleavage of the wafer as a pattern configuration is easy to be acquired -- as -- a configuration almost comparable as a chip size, for example, a 400micrometerx400micrometer configuration, -- it comes out and a certain thing is desirable. That is, a pattern is attached and n electrode is formed so that n electrode may not exist on a scribe line and/or a cleavage plane. Furthermore, if a metallizing electrode is also formed on n electrode in the same pattern configuration as n electrode, it will become easy to carry out the scribe of it, and its cleavability will improve. Especially as an n electrode, although not limited, Ti-aluminum, W-aluminum-W-Au, etc. can be used, for example. As a metallizing electrode, 0.1 micrometer-0.2micrometer[ of Ti-Pt-Au-(Au/Sn) [thickness ]-0.7micrometer-0.3micrometer], Like the Ti-Pt-Au-(Au/Si) [thickness above, like] and the Ti-Pt-Au-(Au/germanium) [thickness above, ] etc. can be used like] and the Au/germanium[thickness above like] and the Au/Si[thickness above like] and the [0.3 micrometers of Au/Sn thickness] In[thickness above like the Ti-Pt-Au-In [thickness above. As the approach of chip-izing in case n electrode is formed in a rear face at a pattern configuration, a bar-like sample can be produced for between n electrode patterns on the back by the scribe from a rear face, and a scribe can perform chip-ization from the rear face after reflective mirror formation to an end face, for example.

[0042] Moreover, especially as component structure of others of the laser component of this invention, it is not limited but well-known various component structures can be used. or [ that the nitride semi-conductor of SiO2 grade does not grow on different-species substrates known conventionally, such as sapphire and a spinel, or a different-species substrate as a substrate into which the component structure of the laser component of this invention is grown up ] -- or the protective coat which consists of an ingredient which cannot grow easily forms, and the nitride semi-conductor substrate which is made to carry out lateral

growth (lateral growth) selectively on it, and is obtained is mentioned. A nitride semi-conductor substrate with few crystal defects which are made to carry out lateral growth preferably and are acquired is desirable. When component structure is formed on a nitride semi-conductor substrate with few crystal defects, it is desirable, although the crystal defect of the nitride semi-conductor which constitutes a component decreases and generation of heat within a component is suppressed. Moreover, it becomes easy to carry out cleavage of the substrate to being a nitride semi-conductor substrate, and it is desirable also in respect of peeling prevention of p electrode. The protective coat used when the protective coat used for lateral growth formed said stripe shows a different operation.

[0043] As the growth approach of a nitride semi-conductor substrate with few crystal defects acquired using lateral growth Although it may not be limited but which approach may be used, especially, for example An approach given in J.J.A.P.Vol.37(1998) pp.L309-L312, The concavo-convex section is formed in the nitride semi-conductor front face which these people grew up on a different different-species substrate from the nitride semi-conductor currently indicated by JP,11-191659,A which applied previously. After forming said protective coat of SiO<sub>2</sub> grade on the flat surface of the heights and a crevice, the method of connecting the nitride semi-conductor which grew the longitudinal direction and grew up to be the protective coat upper part in the longitudinal direction mutually from the nitride semi-conductor exposed to the side face etc. is mentioned. Moreover, in case the nitride semi-conductor substrate obtained with lateral growth grows up component structure, even if it performs it in the condition of having a different-species substrate, where a different-species substrate is removed, it may be performed.

[0044] The resonance side of the laser component of this invention can form a good mirror plane-like resonance side by carrying out cleavage in respect of {11-00} of a nitride semi-conductor [the field equivalent to the side face of a Mth page:hexagonal prism-like crystal] so that it may become vertical to the stripe of a ridge configuration. The detail is indicated about the cleavage in the Mth page of a nitride semi-conductor by JP,9-232676,A for which these people applied previously, for example.

[0045]

[Example] The example of the nitride semiconductor laser component which is the gestalt of 1 operation of the following this inventions is shown. However, this invention is not limited to this.

[Example 1] drawing 2 is the typical sectional view showing the structure of the laser component concerning one example of this invention, and shows drawing at the time of cutting in a direction vertical to stripe waveguide. Hereafter, an example 1 is explained based on this drawing.

[0046] (Substrate layer 2) The different-species substrate 1 which consists of sapphire which makes 1inchphi and C side a principal plane is set in a MOVPE reaction container, temperature is made into 500 degrees C, and the buffer layer which consists of GaN is grown up by 200A thickness using trimethylgallium (TMG) and ammonia (NH<sub>3</sub>). Temperature is made into 1050 degrees C after buffer layer growth, and the substrate layer 2 which similarly consists of GaN is grown up by 4-

micrometer thickness. This substrate layer forms a protective coat in a front face selectively, and acts as a substrate layer for next performing selective growth of a nitride semi-conductor substrate.

[0047] (Protective coat 3) The protective coat 3 which forms a stripe-like photo mask in the front face of ejection and this substrate layer from a reaction container, and consists a wafer of  $\text{SiO}_2$  with a stripe width of face [ of 10 micrometers ] and a stripe spacing (window part) of 2 micrometers with PVD equipment is formed after substrate layer growth.

[0048] (Nitride semi-conductor substrate 4) A wafer is again set in the reaction container of MOVPE after protective coat formation, temperature is made into 1050 degrees C, and the nitride semi-conductor substrate 4 which consists of undoping GaN is grown up by 20-micrometer thickness using TMG and ammonia. The double or more figures crystal defect of this nitride semi-conductor substrate decreases as compared with 2 or less [  $10^5$  //cm ] and substrate layers 2 in order to grow up to be a longitudinal direction in the protective coat 3 upper part.

[0049] (n mold contact layer 5) Next, n mold contact layer 5 which consists of GaN which doped Si  $3 \times 10^{18}$  -/cm<sup>3</sup> at 1050 degrees C on the nitride semi-conductor substrate 1 is grown up by 4-micrometer thickness, using silane gas as ammonia, TMG, and impurity gas.

[0050] (Crack prevention layer 6) Next, the crack prevention layer 6 which makes temperature 800 degrees C and consists of  $\text{In}_{0.06}\text{Ga}_{0.94}\text{N}$  is grown up by 0.15-micrometer thickness using TMG, TMI (trimethylindium), and ammonia. In addition, this crack prevention layer is omissible.

[0051] (n mold cladding layer 7) Then, the layer which consists of undoping  $\text{Al}_{0.16}\text{Ga}_{0.84}\text{N}$  using TMA (trimethylaluminum), TMG, and ammonia at 1050 degrees C is grown up by 25A thickness, TMA is stopped continuously and the layer which consists of an n mold GaN which doped a sink and Si for silane gas  $1 \times 10^{19}$  -/cm<sup>3</sup> is grown up by 25A thickness. Crosswise lamination of those layers is carried out, a superlattice layer is constituted, and n mold cladding layer 7 which consists of superlattice of the 1.2 micrometers of the total thickness is grown up.

[0052] (n mold lightguide layer 8) Then, n mold lightguide layer 8 which consists silane gas of undoping GaN at a stop and 1050 degrees C is grown up by 0.1-micrometer thickness. n mold impurity may be doped in this n mold lightguide layer 8.

[0053] (Barrier layer 9) Next, temperature is made into 800 degrees C, the barrier layer which consists of Si dope  $\text{In}_{0.05}\text{Ga}_{0.95}\text{N}$  is grown up by 100A thickness, and the well layer which consists of undoping  $\text{In}_{0.2}\text{Ga}_{0.8}\text{N}$  at the same temperature continuously is grown up by 40A thickness. The laminating of a barrier layer and the well layer is carried out twice alternately, finally it is finished as a barrier layer, and the barrier layer of the multiplex quantum well structure (MQW) of the 380A of the total thickness is grown up.

[0054] (p mold cap layer 10) Next, raising, TMG and TMA, ammonia, and  $\text{Cp}_2\text{Mg}$  (magnesium cyclopentadienyl) are used for 1050 degrees C for temperature, and p mold cap layer 7 which consists of p mold  $\text{Al}_{0.3}\text{Ga}_{0.7}\text{N}$  with larger bandgap energy which doped Mg  $1 \times 10^{20}$  -/cm<sup>3</sup> than p mold lightguide layer 11 is grown up by 300A thickness.

[0055] (p mold lightguide layer 11) continuing -- Cp2 -- p mold lightguide layer 11 which bandgap energy becomes from the undoping GaN smaller than p mold cap layer 10 at a stop and 1050 degrees C about Mg and TMA is grown up by 0.1-micrometer thickness.

[0056] (p mold cladding layer 12) then, the layer which consists of undoping aluminum<sub>0.16</sub>Ga<sub>0.84</sub>N at 1050 degrees C is grown up by 25Å thickness -- making -- continuing -- Cp2 -- the layer which consists Mg and TMA of a stop and undoping GaN is grown up by 25Å thickness, and p mold cladding layer 12 which consists of a superlattice layer of the 0.6 micrometers of the total thickness is grown up.

[0057] (p mold contact layer 13) p mold contact layer 13 which finally consists of a p mold GaN which doped Mg  $1 \times 10^{20}$  /cm<sup>3</sup> on p mold cladding layer 9 at 1050 degrees C is grown up by 150Å thickness.

[0058] The protective coat which becomes the front face of p mold contact layer of the ejection from a reaction container and the maximum upper layer from SiO<sub>2</sub> about the wafer into which the nitride semi-conductor was grown up as mentioned above is formed, and it etches by SiCl<sub>4</sub> gas using RIE (reactive ion etching), and as shown in drawing 2, the front face of n mold contact layer 5 which should form n electrode is exposed. Thus, for etching a nitride semi-conductor deeply, it considers as a protective coat, and SiO<sub>2</sub> is the optimal.

[0059] Next, mostly, as shown in drawing 5 (a), after forming the 1st protective coat 61 of p mold contact layer 13 of the maximum upper layer which consists of an Si oxide (mainly SiO<sub>2</sub>) by 0.5-micrometer thickness with PVD equipment, the mask of a predetermined configuration is covered on the 1st protective coat 61, and the 3rd protective coat 63 which consists of a photoresist is formed in the whole surface by 1 micrometer in stripe width of face of 2 micrometers, and thickness.

[0060] Next, as shown in drawing 5 (b), said 1st protective coat 61 is etched by using the 3rd protective coat 63 as a mask using CF<sub>4</sub> gas after the 3rd protective coat 63 formation and with RIE (reactive ion etching) equipment, and it considers as the shape of a stripe. By processing with an etching reagent after that and removing only a photoresist, as shown in drawing 5 (c), the 1st protective coat 61 with a stripe width of face of 2 micrometers can be formed on p mold contact layer 13.

[0061] Furthermore, as shown in drawing 5 (d), after the 1st protective coat 61 formation of the shape of a stripe, p mold contact layer 13 and p mold cladding layer 12 are again etched using SiCl<sub>4</sub> gas by RIE, and a stripe-like waveguide field (ridge stripe in this case) is formed. The transverse mode is [ that it is easy to become a single mode ] dramatically desirable when it is the configuration of an order mesa where the cross-section configuration of the stripe is shown in drawing 2, in case a stripe is formed.

[0062] Where the film for protecting so that a rich layer may not be formed in p mold contact layer 13, after forming the stripe of a ridge configuration is attached, on the flat surface which is continuing from the side face of the stripe of a ridge configuration, and its side face, aluminum is vapor-deposited with PVD equipment and the vacuum evaporation film is formed [ drawing 5 (e-1)]. Next, in an

annealing furnace, it heat-treats by applying predetermined time amount and heat. Then, an acid removes the vacuum evaporation film of aluminum. Thus, the rich layer 201 is formed like drawing 5 (e-2).

[0063] A wafer is transported to PVD equipment after forming the rich layer 201, and as shown in drawing 5 (f), the 2nd protective coat 62 which consists of a Zr oxide (mainly ZrO<sub>2</sub>) is continued and formed by 0.5-micrometer thickness on p mold cladding layer 12 exposed by etching the 1st protective coat 61 top.

[0064] Next, as it is immersed in fluoric acid and a wafer is shown in drawing 5 (g), the 1st protective coat 61 is removed by the lift-off method.

[0065] Next, as shown in drawing 5 (h), the p electrode 20 which consists of nickel/Au is formed in the front face of the p mold contact layer which the 1st protective coat 61 on p mold contact layer 13 was removed, and was exposed. However, as stripe width of face of 100 micrometers, the p electrode 20 is gone across and formed on the 2nd protective coat 62, as shown in this drawing 5 (h).

[0066] Next, succeeding the whole surface on the p electrode 20, the 1st thin film layer 31 which consists of Ti is formed by 1000Å thickness, and as further shown in drawing 2, the 1st thin film layer 31 is formed in the side face of a stripe etc.

The upper part of the magnitude which is not in agreement with the cleavage plane at the time of forming a resonance side by cleavage at a next process on this 1st thin film layer 31 formed continuously, i.e., the part used as a cleavage plane, is avoided, the 2nd thin film layer 32 which consists of Au intermittently is formed by 8000Å thickness, and p pad electrode 101 which consists of the 1st thin film layer 31 and the 2nd thin film layer 32 is formed.

[0067] The n electrode 21 which consists of Ti/aluminum is formed in the front face of n mold contact layer 5 exposed at the very first in a direction parallel to a stripe after p pad electrode formation, and n pad electrode which consists of Ti/Pt/Au is formed on it.

[0068] After grinding the silicon on sapphire of the wafer which formed n electrode, p electrode, and p pad electrode as mentioned above and being referred to as 70 micrometers, in a direction vertical to a stripe-like electrode, cleavage is carried out to the shape of a bar from a substrate side, and a resonator is produced to a cleavage plane (11 the 00th [ -] page, a hexagon head field = equivalent to the side face of a pillar-shaped crystal Mth page). The dielectric multilayer which consists of SiO<sub>2</sub> and TiO<sub>2</sub> is formed in a resonator side, and, finally it considers as a laser component as cut a bar and shown in drawing 2 in a direction parallel to p electrode. In addition, as for cavity length, it is desirable to be referred to as 300-500 micrometers.

[0069] When this laser component is installed in a heat sink, wire bonding of each electrode is carried out and laser oscillation is tried at a room temperature, in the oscillation wavelength of 400-420nm, and threshold-current consistency 2.9 kA/cm<sup>2</sup>, a room temperature shows a good continuous oscillation. Furthermore, leakage current and a short circuit can be prevented, a laser component with a good life property can be obtained efficiently, and the yield improves because insulation became good.

[0070] In the [example 2] example 1, the rich layer 201 which consists of aluminum is formed by the ion implantation, and also a laser component is produced similarly.

As the approach of an ion implantation, it is in the condition which attached the protective coat to the maximum top face of p mold contact layer 13, and aluminum is accelerated from a wafer top face to predetermined energy with ion implantation equipment, and it is devoted to a wafer. Next, a carrier beam part is heat-treated and a damage is made to recrystallize by the ion implantation. The obtained laser component shows a good component property like an example 1, and its yield also improves further.

[0071] [Example 3] drawing 3 is the typical sectional view showing the structure of the laser component concerning other examples of this invention, and explains an example 3 below based on this drawing.

[0072] (Nitride semi-conductor substrate 40) In an example 1, a wafer is again set to the front face of the substrate layer 2 in the reaction container of MOVPE after stripe-like formation [ protective coat 3 ], temperature is made into 1050 degrees C, and Undoping GaN is grown up by 5-micrometer thickness using TMG and ammonia. Then, a wafer is transported to HVPE (hydride vapor growth) equipment, Ga metal, HCl gas, and ammonia are used for a raw material, and the nitride semi-conductor substrate 40 which consists of undoping GaN is grown up by 200-micrometer thickness. thus, MOVPE -- HVPE after growing up a nitride semi-conductor on a protective coat 3 by law -- if a GaN thick film 100 micrometers or more is grown up by law, even if it compares a crystal defect with an example 1, it will be acquired, and will decrease single or more figures. After nitride semi-conductor substrate 40 growth, polish removes the ejection from a reaction container, silicon on sapphire 1, a buffer layer 2, a protective coat 3, and an undoping GaN layer, and let a wafer be independent [ nitride semi-conductor substrate 40 ].

[0073] The rest carries out the laminating even of n mold contact layer 5 - the p mold contact layer 13 on the nitride semi-conductor substrate 40 of an opposite hand a polish side like an example 1.

[0074] Like an example 1 after p mold contact layer 13 growth, let an etching stop be the front face of n mold contact layer 5 in the 2nd process after forming the stripe-like 1st protective coat 61. The rest forms an electrode in each contact layer, after forming in the side face of stripe waveguide, and the front face of n mold contact layer 5 the 2nd protective coat 62 which uses ZrO<sub>2</sub> as a principal component after forming the rich layer 201 which consists of aluminum like an example 1. Next, p pad electrode 101 is formed like an example 1, and it considers as the laser component of structure as shown in drawing 3 . In addition, when forming a resonance side, the cleavage plane of a nitride semi-conductor substrate may be the Mth same page as an example 1. A threshold-current consistency falls [ the obtained laser component ] even to 1.8 kA/cm<sup>2</sup> as compared with an example 1, a life can improve by 3 or more times, leakage current and a short circuit can prevent good by insulating improvement still like an example 1, and the laser component which has a good life property can be produced with the sufficient yield.

[0075] [Example 4] drawing 4 is the typical sectional view showing the structure of the laser component concerning other examples of this invention, and explains an example 4 using this drawing 4 below.

[0076] In an example 3, in case the nitride semi-conductor substrate 40 is produced, in HVPE equipment, silane gas is added to a raw material, and the nitride semi-conductor substrate 50 which consists of GaN which doped Si  $1 \times 10^{18}$  - /cm<sup>3</sup> is grown up by 200-micrometer thickness. In addition, as for Si concentration, it is desirable to consider as the range of three to  $5 \times 10^{19}$  /cm<sup>3</sup> of  $1 \times 10^{17}$  - /cm. Silicon on sapphire 1, a buffer layer 2, a protective coat 3, and an undoping GaN layer are ground and removed like an example 3 after nitride semi-conductor substrate 50 growth, and it considers as nitride semi-conductor substrate 50 simple substance.

[0077] Next, laminating growth even of the crack prevention layer 6 - the p mold contact layer 13 is carried out like an example 1 on this nitride semi-conductor substrate 50. Like an example 1 after p mold contact layer 13 growth, after forming the stripe-like 1st protective coat 61, in the 2nd process, it considers as the front face of n mold cladding layer 7 which shows an etching stop to drawing 5 . Like an example 1, the rest forms the rich layer 201, and after that, after it forms in the side face of stripe waveguide, and the front face of n mold cladding layer 7 the 2nd protective coat 62 which uses ZrO<sub>2</sub> as a principal component, it forms the p electrode 20 through the 2nd protective coat.

[0078] The 1st thin film layer 31 which consists of Ti on the p electrode 21 so that it may become stripe die length and the same die length next, by 1000Å of thickness The 3rd thin film layer which consists of Pt in the configuration of the 2nd thin film layer 32, and the same configuration by 1000Å of thickness And p pad electrode 101 which comes to carry out laminating formation of the 2nd thin film layer 32 which consists of Au in a configuration shorter than stripe die length by 8000Å of thickness at order is formed as shown in drawing 4 . Although the 3rd thin film layer is not illustrated, it forms in the same configuration as the 2nd thin film layer. on the other hand -- the rear-face side of a nitride semi-conductor substrate -- the n electrode 21 is mostly formed in the whole surface. After electrode formation, cleavage is carried out by the Mth page of a nitride semi-conductor substrate, and a resonance side is produced and it considers as the laser component of structure as shown in drawing 4 .

[0079] [Example 5] As shown in the laser component of drawing 6 which shows the laser component indicated by said J.J.A.P. at drawing 1 , the laser component which comes to form the rich layer 201 like an example 1 is produced. Insulation can become good, and the obtained laser component can prevent generating of leakage current, and generating of a short circuit, and can produce a component with a good life property with the sufficient yield.

[0080] In the [example 6] example 1, the laser component which has it come to form the rich layer 201 which change to aluminum, and B is used, and also contains B in abundance by diffusion similarly is produced. Consequently, a good result almost equivalent to an example 1 is obtained.

[0081] In the [example 7] example 2, the laser component which has it come to form the rich layer 201 which change to aluminum, and B is used, and also contains B in abundance by the ion implantation similarly is produced. Consequently, a good result almost equivalent to an example 1 is obtained.

[0082]

[Effect of the Invention] The nitride semiconductor laser component of this



invention can produce the laser component which an insulator layer (the 2nd protective coat is included ) and a rich layer act in multiplication , and has good insulation by forming the rich layer which contains aluminum or B in abundance near the front face of the flat surface which is continuing as mentioned above from the side face of the stripe of the rich configuration of component structure , and its side face . And prevention can prevent prevention and a short circuit of leakage current, and a laser component with a good life property can be obtained with the sufficient yield. Furthermore, according to the condition of formation of a rich layer, this invention can make slight optical closing depth good, becomes possible [ changing into the component structure of a perfect refractive-index mold ], even if it is the component structure of an effective-index mold, and serves as a desirable laser component in respect of stabilization of the level transverse mode, or lowering of a threshold.

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[Translation done.]

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TECHNICAL FIELD

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[Industrial Application] Especially insulation of this invention is good about the laser component which consists of a nitride semi-conductor ( $\text{In}_a\text{Al}_b\text{Ga}_{1-a-b}\text{N}$ ,  $0 \leq a$ ,  $0 \leq b$ ,  $a+b \leq 1$ ), and it is related with the long nitride semiconductor laser component of the life from which leakage current and a short circuit were prevented.

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[Translation done.]

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**PRIOR ART**

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[Description of the Prior Art] In recent years, many researches and developments are done for utilization of a nitride semiconductor laser component, and various nitride semiconductor laser components are known. this invention person etc. as a usable laser component for example, to Jpn.J.Appl.Phys.Vol.37(1998) pp.L309-L312, Part2, No.3B, and 15 March 1998 20 micrometers (Epitaxially laterally overgrown GaN) of ELOG(s) are formed in the silicon-on-sapphire upper part. After growing up GaN after that until thickness is set to 100 micrometers, the GaN substrate with which about 80-micrometer rearrangement was reduced was obtained by deleting silicon on sapphire, and the nitride semiconductor laser component which comes to carry out two or more laminatings of the nitride semiconductor layer which serves as laser component structure on this GaN substrate is announced. And this laser component announced the nitride semiconductor laser component which makes possible 10,000 hours or more of continuous oscillation in a room temperature. The same typical sectional view as the laser component shown in drawing 6 at above-mentioned J.J.A.P. was shown. As shown in this drawing 6, it has the stripe of the ridge configuration which etched selectively and was formed to p mold cladding layer which consists of a p mold contact layer which consists of p-GaN from the superstructure of p-aluminum<sub>0.14</sub>Ga<sub>0.86</sub>N/GaN. It is the nitride semiconductor laser component which the insulator layer which benefits the insulation of a component from SiO<sub>2</sub> is formed in the side face of the stripe of the formed ridge configuration, and p electrode is further formed in said stripe upper part, and comes to form a resonance side by cleavage. Furthermore, p pad electrode is formed so that this laser component may cover p electrode. Thus, by forming the insulator layer in the side face of the stripe of a ridge configuration, prevention of a short circuit and prevention of leakage current are performed.

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## EFFECT OF THE INVENTION

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[Effect of the Invention] The nitride semiconductor laser component of this invention can produce the laser component which an insulator layer (the 2nd protective coat is included ) and a rich layer act in multiplication , and has good insulation by forming the rich layer which contains aluminum or B in abundance near the front face of the flat surface which is continuing as mentioned above from the side face of the stripe of the rich configuration of component structure , and its side face . And prevention can prevent prevention and a short circuit of leakage current, and a laser component with a good life property can be obtained with the sufficient yield. Furthermore, according to the condition of formation of a rich layer, this invention can make slight optical closing depth good, becomes possible [ changing into the component structure of a perfect refractive-index mold ], even if it is the component structure of an effective-index mold, and serves as a desirable laser component in respect of stabilization of the level transverse mode, or lowering of a threshold.

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**TECHNICAL PROBLEM**

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[Problem(s) to be Solved by the Invention] However, in the obtained laser component, in spite of being the laser component formed on the same conditions, what has an extremely bad life property arises. As a result of examining many things about the cause that a life property falls extremely, since the insulation of the insulator layer of the side face of the stripe of a ridge configuration was imperfect, leakage current arose and this invention person surmised that it was for a short circuit to occur. To both attain improvement in the yield as if for \*\* which suited commercializing a laser component to make component properties, such as a life property, good is desired.

[0004] Then, the object of this invention is offering the nitride semiconductor laser component which can make the insulation of a component good, can prevent prevention and a short circuit of leakage current, and can obtain a component with a good life property with the sufficient yield.

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MEANS

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[Means for Solving the Problem] That is, the configuration of following the (1) - (3) can attain the object of this invention.

(1) It has the component structure of making n mold nitride semi-conductor layer, a barrier layer, and p mold nitride semi-conductor layer coming to grow up at least on a substrate. In the nitride semiconductor laser component which etching comes to form the stripe of a ridge configuration from p mold nitride semi-conductor layer side, and comes to form an insulator layer in the side face of the stripe of said ridge configuration further at least The nitride semiconductor laser component characterized by having the rich layer which contains aluminum or boron at abundance near the front face of the flat surface which is in contact with said insulator layer, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least.

(2) A nitride semiconductor laser component given in the above (1) characterized by coming to form said rich layer in the front face of the flat surface which is exposed, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least by diffusing aluminum or boron after forming the stripe of a ridge configuration.

(3) A nitride semiconductor laser component given in the above (1) characterized by said rich layer carrying out the ion implantation of aluminum or the boron to the front face of the flat surface which is exposed, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least, and coming to form it in it after forming the stripe of a ridge configuration.

[0006] That is, by forming the rich layer which make abundance come to contain aluminum or boron toward the interior near [ , such as a side face of the stripe of a ridge configuration , ] a front face from a front face , this invention act in multiplication with the insulator layer form in the side face of the stripe of a ridge configuration , and the good insulation of it be attain , and it can offer the nitride semiconductor laser component which become possible [ preventing leakage current and a short circuit good ] . Furthermore, this invention can also attain improvement in the yield by considering as the laser component which has a rich layer.

[0007] Conventionally, as shown in drawing 6 , the insulating insulator layer is formed in the side face of the stripe of a ridge configuration. However, the case where this insulator layer is not uniform good film will arise, insulation will become

imperfect, and a short circuit etc. will occur.

[0008] On the other hand, the result examined variously that this invention person should make the insulation of the part which touches a pad electrode a much more perfect thing, Make aluminum (aluminum) or boron (B) contain near the front face of the flat surface which is continuing from the side face of a stripe, and the side face of a stripe in abundance, and a rich layer is formed. By making into insulation the front face of the component structure exposed by forming the stripe of a ridge configuration itself, a rich layer and an insulator layer can act in multiplication, and can have good insulation.

[0009] furthermore, the thing make for front faces, such as a side face of the stripe of a ridge configuration expose, to diffuse aluminum or boron after a rich layer forming the stripe of a ridge configuration in this invention — or when it come to be form by carrying out the ion implantation of aluminum or the boron, while being able to form a rich layer good and showing better insulation, it be desirable in respect of improvement in the yield.

[0010] Moreover, in this invention, when an ion implantation is carried out, the refractive index of the part is desirable in aluminum or B, also at diffusion or the point which becomes small and light shuts up. From this, although the laser component of drawing 6 is an effective-index waveguide mold since p electrode has not touched all over the front face of p mold contact layer, for example An ion implantation is spread or carried out. aluminum or B to the side face of a barrier layer 9 for the laser component of drawing 6 , as shown in drawing 1 By forming the rich layer 201, it becomes a perfect refractive-index waveguide mold because slight optical closing depth becomes good, and the level transverse mode can be stable, lifting of a threshold can be prevented, a life property can be raised, and it is desirable.

[0011]

[Embodiment of the Invention] Drawing 1 – drawing 4 are used for below, and this invention is further explained to it at a detail. Drawing 1 is the typical sectional view showing the part cut at right angles to the die-length direction of the stripe of the ridge configuration of the nitride semiconductor laser component which is the gestalt of the 1 operation which comes to form the rich layer 201 of this invention in the laser component of drawing 6 shown with said conventional technique. Drawing 2 – drawing 4 are the typical sectional views of the nitride semiconductor laser component which is the gestalt of the 1 operation which comes to form the rich layer 201 of this invention in the laser component used as a perfect refractive-index waveguide mold.

[0012] The nitride semiconductor laser component of this invention has the rich layer which contains aluminum or boron at abundance near the front face of the flat surface which is in contact with the insulator layer, and which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe at least in the nitride semiconductor laser component which comes to form an insulator layer in the side face of the stripe of a ridge configuration. Therefore, especially as a laser component which forms a rich layer, it is not limited but, specifically, the laser component of drawing 1 – drawing 4 is mentioned that what is necessary is just the laser component which has the stripe of a ridge

configuration.

[0013] First, the rich layer 201 is explained using drawing 1. An insulator layer is formed in the side face of the stripe of a ridge configuration at drawing 1, the p electrode 20 is formed in the maximum upper layer of a stripe, and p pad electrode is formed in the upper part part of a stripe so that p electrode and an electric target may be contacted. And the rich layer 201 is formed near the front face of the flat surface which is continuing from the side face of the stripe of a ridge configuration in which the insulator layer 62 is in contact with component structure, and the side face of a stripe. after protect formation of the rich layer 201 in the case of this drawing 1 so that the rich layer 201 may not be form in the maximum top face ( front face of p mold contact layer ) of p mold nitride semiconductor layer, after form the stripe of a ridge configuration, it be make to contain near the front face which be have aluminum or B expose by diffusion and the ion implantation in abundance in the process of formation of the conventional component.

[0014] In this invention, near a front face shows the part which has the depth toward the inside from the front face of the exposed component structure, after forming the stripe of a ridge configuration. For example, the part in which the rich layer 201 shown in drawing 1 -4 is formed is shown. Moreover, in this invention, though it is the same layer as containing in abundance like p mold contact layer of drawing 2, and p mold cladding layer, more aluminum or B than other parts are contained, and the condition that aluminum and B are unevenly distributed is shown. And the part in which aluminum and B are unevenly distributed is used as the rich layer 201 by this invention.

[0015] In this invention, after formation of the rich layer 201 forms the stripe of a ridge configuration, it is formed in the exposed part by making aluminum or B contain near the front face of the part where especially p pad electrode is formed in an upper part part at abundance. Especially as an approach of making abundance containing aluminum and B, although not limited, after making a part to form a rich layer in vapor-deposit aluminum and B, in this invention, the method of applying and diffusing heat or the approach by the ion implantation is mentioned, for example as a desirable example.

[0016] In this invention, it heat-treats by making the part to diffuse vapor-deposit aluminum or B as an approach of diffusing. As temperature in the case of heat treatment, it is adjusted suitably, for example, is 400 degrees C - 700 degrees C. As time amount of heat treatment, it is adjusted suitably, for example, is 10 minutes - 2 hours. Moreover, when forming the rich layer 201 by diffusion, adjustment of concentration and accommodation of the depth from a front face are performed by adjusting the temperature and time amount of heat treatment.

[0017] aluminum or B which the mask of the part to make it pouring in was carried out [ B ], and made it ionize all over a wafer by Si oxide film or the resist as an approach of carrying out an ion implantation in this invention -- 10- it is carried out by accelerating to the energy of hundreds keV(s) and devoting oneself to a front face. Moreover, when forming the rich layer 201 by the ion implantation, adjustment of concentration and accommodation of the depth from a front face are performed by adjusting impregnation time amount in acceleration voltage.



[0018] Moreover, it is extent which is limited and can take \*\*\*\* and insulation especially as aluminum of the rich layer 201, or concentration of B, for example, they are specifically three or more  $1 \times 10^{14}$  atom/cm. Moreover, although especially the thickness (depth from a front face) of the rich layer 201 is not limited, it is extent which can take insulation, for example, is specifically 100Å – 2 micrometers.

[0019] for example, as a gestalt of 1 implementation of formation of the ridge layer 201 On a substrate as indicated by J.J.A.P. shown with said conventional technique n mold contact layer, From p mold nitride semi-conductor layer side after forming the component structure of making a barrier layer, p mold contact layer, etc. coming to grow up, by etching etc. After forming the stripe of a ridge configuration, Where a rich layer is made not to be formed in the front face of the maximum upper layer of the stripe of a ridge configuration, (in for example, the condition that protective coats, such as a resist formed on the occasion of etching, are formed) The ridge layer 201 is formed at least by the diffusion and the ion implantation which are exposed and which were shown in the side face of the stripe of a ridge configuration etc. above. Then, an insulator layer 15, the p electrode 20, and p pad electrode 101 grade are formed like said J.J.A.P. etc. And it becomes the laser component which has the rich layer 201 shown in drawing 1. Especially as an insulator layer 62 of drawing 1, although not limited, SiO<sub>2</sub> grade can be used. Moreover, especially as a stripe of the ridge configuration of drawing 1, although not limited, the content indicated by J.J.A.P. shown above, for example and the same content are mentioned.

[0020] By forming the rich layer 201, the rich layer 201 and an insulator layer 15 act in multiplication, insulation becomes good, and the laser component shown in drawing 1 can perform prevention of leakage current, and prevention of a short circuit, and turns into a laser component with a good life property. In case the laser component furthermore shown in drawing 1 can be produced with the sufficient yield and mass-produced, it is desirable. Since insulation becomes good [ the laser component of this invention ], furthermore, the desirable laser component shown in drawing 1 again also in respect of the improvement in the dependability of a component (defect prevention) Although nonuniformity arises in current density inside the stripe of a ridge configuration, the level transverse mode becomes unstable and lifting of a threshold may be seen in the condition of not forming the rich layer 201 since p electrode has not touched all over the front face of p mold contact layer A component property like the laser component of a perfect refractive-index waveguide mold becomes easy to be shown by the refractive index of the part becoming small by making aluminum or B contain, and slight optical closing depth becoming good. Thus, if lifting of a threshold is suppressed, a life property can be made more into fitness. The rich layer 201 shown in drawing 1 can adjust thickness by adjusting suitably according to the diffusion at the time of forming the rich layer 201, or the conditions of an ion implantation, although horizontal thickness differs from vertical thickness to a substrate. The thickness of a rich layer shows whether aluminum or B has entered to the depth of how much in component structure here.

[0021] Next, the laser component of drawing 2 – drawing 4 is explained. By the

whole surface surface of p mold contact layer having touched p electrode, since stripe width of face is narrow, the level transverse mode stabilizes drawing 2 - drawing 4 , since they can suppress lifting of a threshold, they are desirable, and they serve as still more desirable structure as a laser component of a perfect refractive-index waveguide mold. Laminating growth of n mold contact layer 5 - the p mold contact layer 13 is carried out on a substrate at drawing 2 - drawing 5 . The stripe of a ridge configuration is formed by etching from this p mold contact layer side. As the 2nd protective coat 62 (insulating film equivalent to the insulator layer of this invention) is formed in the side face of the stripe of a ridge configuration and p mold contact layer which is the maximum upper layer of a stripe is touched, they are p electrode and the laser component which p pad electrode is formed and becomes so that p electrode may be touched further. Here, although the 2nd protective coat 62 is formed in order to be the insulating film, to be equivalent to the insulator layer of this invention and to maintain the insulation of a component like the insulator layer 15 of drawing 1 , it is faced explaining the phase of formation of drawing 2 - drawing 5 , and let it be the 2nd protective coat 62. And the rich layer 201 of this invention is formed in the flat surface which is continuing from the side face of the stripe of a ridge configuration, and the side face of a stripe as shown in each drawing at such drawing 2 - drawing 5 . By forming the rich layer 201, insulation is shown, it acts in multiplication with the 2nd insulating protective coat 62 currently formed in the side face of a stripe, and the part of the rich layer 201 also makes the insulation of a component good. Prevention of leakage current and prevention of a short circuit become good, and the improvement in a life property and improvement in the yield can be attained because insulation becomes good.

[0022] Especially as the 2nd protective coat 62 used as the insulator layer used for drawing 2 - drawing 5 , although not limited, the oxide which contains at least a kind of element chosen from the group which consists of Ti, V, Zr, Nb, Hf, and Ta, BN, SiC, AlN, etc. are mentioned, for example. Moreover, Si oxide can also be used as the 2nd protective coat 62, and it is carried out by choosing the ingredient which is easy to be etched from Si oxide as an ingredient of the 1st protective coat 61 in this case as mentioned later as mentioned later.

[0023] Especially as stripe geometry of drawing 2 - drawing 5 , although not limited, as desirable stripe geometry, the stripe geometry whose stripe width of face is 0.5-4.0 micrometers, for example can be raised. Stripe width of face is desirable in respect of the lowering of a threshold and the stabilization of the level transverse mode by it being the above-mentioned range. Moreover, as stripe width of face described above as a laser component which has the stripe of structure narrow as mentioned above, the laser component of structure as shown in drawing 2 - drawing 4 is mentioned. Even if these laser components narrow stripe width of face, they are obtained by the stripe and the electrode formation approach (specifically indicated by JP,2000-4063,A.) of forming with sufficient repeatability. Drawing 5 is used and explained about the approach below. By choosing an ingredient so that the etch rates by etching processing with the 1st protective coat 61 used in case the waveguide of a stripe is formed, and the 2nd insulating protective coat 62 formed in the side face of a stripe may differ, and performing

following each process, this approach can form a stripe with sufficient repeatability, and can form the 2nd insulating protective coat 62 in a position by the thickness of homogeneity further.

[0024] Drawing 5 is the typical sectional view showing the partial structure of the nitride semiconductor wafer in each process for explaining each process of the stripe of the nitride semiconductor laser component of drawing 2 - drawing 4, and the formation approach of an electrode. The sectional view shown in this drawing 5 shows drawing at the time of it being parallel and cutting to a perpendicular direction, i.e., a resonance side, to the stripe waveguide formed by etching.

[0025] First, in the 1st process, as shown in drawing 5 (c), the stripe-like 1st protective coat 61 is formed on p mold contact layer 13 in the maximum upper layer. In this 1st process, as long as the 1st protective coat 61 is an ingredient which does not ask especially insulation but has the etch rate and difference of a nitride semi-conductor, what kind of ingredient is sufficient as it. As the 1st protective coat 61, although choosing and using the ingredient with which the 2nd protective coat 62 formed at the 3rd below-mentioned process differs from an etch rate forms the 2nd protective coat 62, it is still more desirable. As the 1st protective coat 61, for example, Si oxide ( $\text{SiO}_2$  is included), a photoresist, etc. are mentioned, and it is Si oxide preferably. Although wet etching, dry etching, etc. are used as an approach it will form the waveguide field of the shape of a stripe of the nitride semiconductor laser component in the 2nd following process if the 1st protective coat 61 is Si oxide, the dry etching which etching tends to carry out is used preferably, and can make good selectivity of the 1st protective coat 61 and nitride semi-conductor to which importance is attached by this dry etching. Moreover, it is easy to dissolve to fluoric acid and is desirable when fluoric acid is used as an acid which has the property which is easy to dissolve rather than the 2nd protective coat by etching which will be performed using an acid at the 3rd process which is an after process if the 1st protective coat 61 is chosen from the above-mentioned ingredient to an acid, is easy to establish a solubility difference with the 2nd protective coat 62, and is used especially at the 3rd process. As stripe width of face (W) of the 1st protective coat, 4 micrometers - 0.5 micrometers are preferably adjusted to 3 micrometers - 1 micrometer. The stripe width of face of the 1st protective coat 61 is about equivalent to the stripe width of face of a waveguide field.

[0026] In the 1st process, the process shown in drawing 5 (a) and (b) is mentioned as a concrete process which forms the 1st protective coat 61. First, as shown in drawing 5 (a), after [ the front face of p mold contact layer 13 ] forming in the whole surface mostly, the stripe-like 3rd protective coat 63 is formed for the 1st protective coat 61 on the 1st protective coat 61. Then, as shown in drawing 5 (b), after etching the 1st protective coat 61, with the 3rd protective coat 63 attached, the 1st protective coat 61 of the shape of a stripe as shown in drawing 5 (c) can be formed by removing the 3rd protective coat 63. In addition, etching gas or an etching means can be changed with the 3rd protective coat 63 attached, and it can also etch from p mold contact layer 13 side.

[0027] In the 1st process, in order to be able to use dry etching like RIE (reactive ion etching), for example and to etch the 1st protective coat 61 which consists of

Si oxide at the 1st process in this case as an etching means, it is desirable to use the gas of a fluorine compound system like CF<sub>4</sub>.

[0028] Moreover, the 1st protective coat 61 of the shape of a stripe as shown in drawing 5 (c) can also be formed by the lift-off method. By the lift-off method, by forming the photoresist of the configuration which the stripe-like hole opened on p mold contact layer 13, forming the 1st protective coat 61 the whole surface from the photoresist, and carrying out dissolution clearance of the photoresist after that, as shown in drawing 5 (c), it leaves only the 1st protective coat 61 in contact with p mold contact layer 13. In addition, as an approach of forming the 1st protective coat 61, it is in the inclination for the stripe with which an end face is [ to form by etching, as shown in drawing 5 (a) and (b) ] almost more nearly vertical, and the configuration was ready to be easy to be obtained rather than it forms the stripe-like 1st protective coat 61 by the lift-off method.

[0029] Next, in the 2nd process, as shown in drawing 5 (d), it etches from the part in which the 1st protective coat 61 of p mold contact layer 13 in which the 1st protective coat 61 was formed is not formed, and the waveguide field of the shape of a stripe according to the configuration of a protective coat is formed in a part for the direct lower part of the 1st protective coat 61. When etching, the structure of a laser component differs from a property by into which location a dirty stop is made. As long as a dirty stop is a layer below p mold contact layer, it may be stopped in any nitride semi-conductor layer. In the example shown in drawing 5, the middle of p mold cladding layer 12 under p mold contact layer 13 is considered as the dirty stop. If a substrate side is a dirty stop from the soffit side of p mold cladding layer rather than the 0.2 micrometers of the directions of p mold contact layer, a stripe will serve as a ridge and the laser component of a refractive-index waveguide mold will be made. A soffit side points out the field of the bottom cladding layer to the thickness direction, and as stated also in advance, when a lightguide layer is under a cladding layer, the interface of a guide layer and a cladding layer is equivalent to a soffit side. If a dirty stop is carried out above this soffit side, since etching time will become short and it will be easy to control an etching rate, convenience on industrial engineering is good.

[0030] Moreover, a dirty stop can also be used as the nitride semi-conductor below the soffit side of p mold cladding layer although not shown in drawing 5. When the layer by the side of a substrate is a dirty stop, it is [ an inclination for a threshold to fall remarkably ] and is more desirable than a soffit side.

[0031] In the 2nd process, as an etching means, although wet etching, dry etching, etc. are used, the dry etching which etching tends to carry out is used preferably. For example, if dry etching like RIE (reactive ion etching) can be used, the gas of a chlorine system like Cl<sub>2</sub>, CCl<sub>4</sub>, and SiCl<sub>4</sub> used well at other groups III-V semiconductor to etch a nitride semi-conductor in this case is used and these gas is used, when Si oxide is used as the 1st protective coat 61, since a selection ratio with Si oxide is made greatly, it is desirable.

[0032] After etching as shown in (d) of drawing 5, and forming the stripe of a ridge configuration, the rich layer 201 is formed. The approach of formation of the rich layer 201 is as having described above. The condition of having formed vacuum evaporation film, such as aluminum, in the flat surface which is continuing from

the side face of the stripe of a ridge configuration and its side face by vacuum evaporation is shown in drawing 5 (e-1). Abundant parts, such as aluminum, are formed toward the interior after forming vacuum evaporation film, such as this aluminum, from the front face of the component structure which is in contact with vacuum evaporation film, such as aluminum, with thermal diffusion. Then, the rich layer 201 can be formed by removing vacuum evaporation film, such as aluminum, as shown in drawing 5 (e-2).

[0033] Next, in the 3rd process, after forming the rich layer 201, as shown in drawing 5 (f), it is an ingredient which is different from the 1st protective coat 61 in the 2nd protective coat 62, and forms using the ingredient which has insulation on the side face of stripe-like waveguide, the flat surface of the nitride semiconductor layer ( drawing 5 (f) p mold cladding layer 12) which it was etched and was exposed, and the 1st protective coat 61. After forming the 2nd protective coat 62, by removing the 1st protective coat 61 by etching, only the 2nd protective coat 62 formed on the 1st protective coat 61 is removed, and as shown in drawing 5 (g), the 2nd protective coat 62 is continuously formed in the side face of a stripe, and the flat surface of p mold cladding layer 12. Thus, in order to make it possible to remove the 1st protective coat 61, without etching the 2nd protective coat 62, as described above, it becomes possible by choosing and using that from which the etch rate to the etching processing performed at the 3rd process differs the ingredient of the 1st protective coat 61 and the 2nd protective coat 62. Although especially etching processing at the 3rd process is not limited, the approach of carrying out dry etching, for example using fluoric acid is mentioned.

[0034] It is chosen from a different ingredient from the 1st protective coat 61 as an ingredient of the 2nd protective coat 62, and it will not be limited, especially if it is the ingredient which is hard to be etched by etching processing of the 3rd process or an etch rate is slower than the 1st protective coat 61 and is the ingredient which can form the 2nd protective coat 62 in the side face of a stripe etc. As the 2nd desirable protective coat, from Si oxide and a resist ingredient being preferably used as the 1st protective coat 61 as mentioned above, it is ingredients other than the ingredient of the 1st protective coat 61 at least, and an ingredient with an etch rate slower than the 1st protective coat 61 is mentioned. When the 1st protective coat 61 is Si oxide, a kind is used for inside [ it is the oxide which contains at least a kind of element chosen from the group which consists of Ti V, Zr, Nb, Hf, and Ta, for example as an example of the 2nd protective coat 62, and BN, SiC and AlN ] at least, and the oxide of Zr, the oxide of Hf, and any one or more sorts of ingredients of BN and SiC are used more preferably. Moreover, after the 2nd protective coat 62 formation, in order not to etch a nitride semi-conductor, the 2nd protective coat 62 is not taken into consideration about etching speed with a nitride semi-conductor. Moreover, as 2nd thin film layer 62, Si oxide may be used and the 1st protective coat 61 is performed in this case by choosing an ingredient with the etch rate quicker than Si oxide in the 3rd process.

[0035] Moreover, like the above, by continuing and forming the 2nd protective coat on the 1st protective coat 61, high insulation can be held, and since it can form by uniform thickness on p mold cladding layer 12, generating of concentration of the

current resulting from the ununiformity of thickness can be prevented. Moreover, in the 2nd process of the above, since the dirty stop is considered as the middle of p mold cladding layer 12, as the 3rd process shows to drawing 5 (f), the 2nd protective coat 62 is formed in the flat surface of p mold cladding layer 12, but if a dirty stop is carried out below p mold cladding layer 12, the 2nd protective coat will be formed in the flat surface of the nitride semi-conductor layer which carried out the dirty stop.

[0036] Moreover, the 2nd protective coat 62 can also be formed by the lift-off method. For example, it is either of the examples which the 2nd protective coat 62 described above, and if the 1st protective coat 61 is used as Si oxide, the 2nd protective coat 62 has the etch selectivity of being hard to be etched or an etch rate is slower than Si oxide, to fluoric acid. For this reason, if only the 1st protective coat 61 is removed by the lift-off method after forming the 2nd protective coat succeeding the side face of stripe waveguide, the flat surface (dirty stop layer) in which that stripe is formed, and the front face of the 1st protective coat 61, as shown in drawing 5 (f), the 2nd protective coat 62 with uniform thickness will be formed to a flat surface as shown in drawing 5 (g).

[0037] Next, in the 4th process, as shown in drawing 5 (h), the p electrode 20 electrically connected with the p mold contact layer 13 is formed on the 2nd protective coat 62 and p mold contact layer 13. Here, since the 2nd protective coat 62 is already formed of said process, in case p electrode is formed, there is no need for fine actuation of forming only in the narrow contact layer of stripe width of face, p electrode can be formed by the large area and operability becomes good.

[0038] moreover, in this invention, when it may have the stripe of the ridge configuration where the above width of face is narrow, as a p pad electrode formed on p electrode The 1st thin film layer which contains the metal which covered whole p electrode surface and was formed by the same die length as stripe die length desirable at least although not limited especially, this -- when it is formed from the 2nd thin film layer containing the metal formed by die length shorter than stripe die length on the 1st thin film layer or comes to form the 3rd thin film layer between the 1st and the 2nd thin film layer, it is desirable, although the cleavability of p pad electrode improves and exfoliation of p electrode is prevented. For example, p pad electrode 101 which comes to form the 2nd thin film layer 32 on the 1st thin film layer 31 shown in drawing 2 used in the below-mentioned example is mentioned.

[0039] The 1st thin film layer is desirable in respect of heat dissipation nature etc. to cleavability, an adhesive property, and a pan in their being more than kinds, such as nickel, Ti, Cr, W, and Pt. Moreover, when the 2nd thin film layer consists of Au, the heat conductivity becomes it is good and good [stripping of heat], and it is still more desirable in respect of the adhesive property in the case of bonding, relaxation of an impact, etc. Although the 2nd thin film layer which consists of Au is inferior in cleavability, since it is a configuration shorter than stripe die length, the end face of the 2nd thin film layer is not in agreement with the cleavage plane formed of cleavage, and does not affect the cleavability of p pad electrode at all. Moreover, when the 3rd thin film layer containing at least one or more sorts of

ingredients, such as Pt, W, TiN, Cr, and nickel, is formed between the 1st thin film layer and the 2nd thin film layer, it can prevent that the 3rd thin film layer turns into a barrier layer, and the metal of the 2nd thin film layer is spread, and is desirable. Thus, when diffusion of the 2nd thin film layer can be prevented, it is desirable for lifting of resistance and lifting of a threshold being suppressed, and generating of the heat inside a laser component being prevented by it, and raising a life property.

[0040] In this invention, the electrode which has the ohmic contact which can choose various ingredients suitably, and can use them as p and an n electrode, for example, is indicated by said J.J.A.P. is mentioned.

[0041] Moreover, in order to be obstructed by n electrode, and for a scribe not to attain even a nitride semi-conductor and to prevent this trouble if SUKURAI BUSU [ a substrate rear face / solid one / n electrode ] from an after [ formation ] rear face when n electrode is formed in a substrate rear face, by forming n electrode of a pattern configuration in the substrate rear face of a wafer, it becomes easy to carry out a scribe and cleavability improves. the configuration of one chip obtained by carrying out cleavage of the wafer as a pattern configuration is easy to be acquired -- as -- a configuration almost comparable as a chip size, for example, a 400micrometerx400micrometer configuration, -- it comes out and a certain thing is desirable. That is, a pattern is attached and n electrode is formed so that n electrode may not exist on a scribe line and/or a cleavage plane. Furthermore, if a metallizing electrode is also formed on n electrode in the same pattern configuration as n electrode, it will become easy to carry out the scribe of it, and its cleavability will improve. Especially as an n electrode, although not limited, Ti-aluminum, W-aluminum-W-Au, etc. can be used, for example. As a metallizing electrode, 0.1 micrometer-0.2micrometer[ of Ti-Pt-Au-(Au/Sn) [thickness] - 0.7micrometer-0.3micrometer], Like the Ti-Pt-Au-(Au/Si) [thickness above, like] and the Ti-Pt-Au-(Au/germanium) [thickness above], ] etc. can be used like] and the Au/germanium[thickness above like] and the Au/Si[thickness above like] and the [0.3 micrometers of Au/Sn thickness] In[thickness above like the Ti-Pt-Au-In [thickness above. As the approach of chip-izing in case n electrode is formed in a rear face at a pattern configuration, a bar-like sample can be produced for between n electrode patterns on the back by the scribe from a rear face, and a scribe can perform chip-ization from the rear face after reflective mirror formation to an end face, for example.

[0042] Moreover, especially as component structure of others of the laser component of this invention, it is not limited but well-known various component structures can be used. or [ that the nitride semi-conductor of SiO<sub>2</sub> grade does not grow on different-species substrates known conventionally, such as sapphire and a spinel, or a different-species substrate as a substrate into which the component structure of the laser component of this invention is grown up ] -- or the protective coat which consists of an ingredient which cannot grow easily forms, and the nitride semi-conductor substrate which is made to carry out lateral growth (lateral growth) selectively on it, and is obtained is mentioned. A nitride semi-conductor substrate with few crystal defects which are made to carry out lateral growth preferably and are acquired is desirable. When component structure

is formed on a nitride semi-conductor substrate with few crystal defects, it is desirable, although the crystal defect of the nitride semi-conductor which constitutes a component decreases and generation of heat within a component is suppressed. Moreover, it becomes easy to carry out cleavage of the substrate to being a nitride semi-conductor substrate, and it is desirable also in respect of peeling prevention of p electrode. The protective coat used when the protective coat used for lateral growth formed said stripe shows a different operation.

[0043] As the growth approach of a nitride semi-conductor substrate with few crystal defects acquired using lateral growth Although it may not be limited but which approach may be used, especially, for example An approach given in J.J.A.P.Vol.37(1998) pp.L309-L312, The concavo-convex section is formed in the nitride semi-conductor front face which these people grew up on a different different-species substrate from the nitride semi-conductor currently indicated by JP,11-191659,A which applied previously. After forming said protective coat of SiO<sub>2</sub> grade on the flat surface of the heights and a crevice, the method of connecting the nitride semi-conductor which grew the longitudinal direction and grew up to be the protective coat upper part in the longitudinal direction mutually from the nitride semi-conductor exposed to the side face etc. is mentioned. Moreover, in case the nitride semi-conductor substrate obtained with lateral growth grows up component structure, even if it performs it in the condition of having a different-species substrate, where a different-species substrate is removed, it may be performed.

[0044] The resonance side of the laser component of this invention can form a good mirror plane-like resonance side by carrying out cleavage in respect of {11-00} of a nitride semi-conductor [the field equivalent to the side face of a Mth page:hexagonal prism-like crystal] so that it may become vertical to the stripe of a ridge configuration. The detail is indicated about the cleavage in the Mth page of a nitride semi-conductor by JP,9-232676,A for which these people applied previously; for example.

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[Translation done.]



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EXAMPLE

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[Example] The example of the nitride semiconductor laser component which is the gestalt of 1 operation of the following this inventions is shown. However, this invention is not limited to this.

[Example 1] drawing 2 is the typical sectional view showing the structure of the laser component concerning one example of this invention, and shows drawing at the time of cutting in a direction vertical to stripe waveguide. Hereafter, an example 1 is explained based on this drawing.

[0046] (Substrate layer 2) The different-species substrate 1 which consists of sapphire which makes 1inchphi and C side a principal plane is set in a MOVPE reaction container, temperature is made into 500 degrees C, and the buffer layer which consists of GaN is grown up by 200A thickness using trimethylgallium (TMG) and ammonia (NH<sub>3</sub>). Temperature is made into 1050 degrees C after buffer layer growth, and the substrate layer 2 which similarly consists of GaN is grown up by 4-micrometer thickness. This substrate layer forms a protective coat in a front face selectively, and acts as a substrate layer for next performing selective growth of a nitride semi-conductor substrate.

[0047] (Protective coat 3) The protective coat 3 which forms a stripe-like photo mask in the front face of ejection and this substrate layer from a reaction container, and consists a wafer of SiO<sub>2</sub> with a stripe width of face [ of 10 micrometers ] and a stripe spacing (window part) of 2 micrometers with PVD equipment is formed after substrate layer growth.

[0048] (Nitride semi-conductor substrate 4) A wafer is again set in the reaction container of MOVPE after protective coat formation, temperature is made into 1050 degrees C, and the nitride semi-conductor substrate 4 which consists of undoping GaN is grown up by 20-micrometer thickness using TMG and ammonia. The double or more figures crystal defect of this nitride semi-conductor substrate decreases as compared with 2 or less [ 105 //cm ] and substrate layers 2 in order to grow up to be a longitudinal direction in the protective coat 3 upper part.

[0049] (n mold contact layer 5) Next, n mold contact layer 5 which consists of GaN which doped Si 3x10<sup>18</sup>-/cm<sup>3</sup> at 1050 degrees C on the nitride semi-conductor substrate 1 is grown up by 4-micrometer thickness, using silane gas as ammonia, TMG, and impurity gas.

[0050] (Crack prevention layer 6) Next, the crack prevention layer 6 which makes temperature 800 degrees C and consists of In<sub>0.06</sub>Ga<sub>0.94</sub>N is grown up by 0.15-

micrometer thickness using TMG, TMI (trimethylindium), and ammonia. In addition, this crack prevention layer is omissible.

[0051] (n mold cladding layer 7) Then, the layer which consists of undoping aluminum $0.16\text{Ga}0.84\text{N}$  using TMA (trimethylaluminum), TMG, and ammonia at 1050 degrees C is grown up by 25A thickness, TMA is stopped continuously and the layer which consists of an n mold GaN which doped a sink and Si for silane gas  $1 \times 10^{19} \text{--}/\text{cm}^3$  is grown up by 25A thickness. Crosswise lamination of those layers is carried out, a superlattice layer is constituted, and n mold cladding layer 7 which consists of superlattice of the 1.2 micrometers of the total thickness is grown up.

[0052] (n mold lightguide layer 8) Then, n mold lightguide layer 8 which consists silane gas of undoping GaN at a stop and 1050 degrees C is grown up by 0.1-micrometer thickness. n mold impurity may be doped in this n mold lightguide layer 8.

[0053] (Barrier layer 9) Next, temperature is made into 800 degrees C, the barrier layer which consists of Si dope  $\text{In}0.05\text{Ga}0.95\text{N}$  is grown up by 100A thickness, and the well layer which consists of undoping  $\text{In}0.2\text{Ga}0.8\text{N}$  at the same temperature continuously is grown up by 40A thickness. The laminating of a barrier layer and the well layer is carried out twice alternately, finally it is finished as a barrier layer, and the barrier layer of the multiplex quantum well structure (MQW) of the 380A of the total thickness is grown up.

[0054] (p mold cap layer 10) Next, raising, TMG and TMA, ammonia, and  $\text{Cp}2\text{Mg}$  (magnesium cyclopentadienyl) are used for 1050 degrees C for temperature, and p mold cap layer 7 which consists of p mold aluminum $0.3\text{Ga}0.7\text{N}$  with larger bandgap energy which doped Mg  $1 \times 10^{20} \text{--}/\text{cm}^3$  than p mold lightguide layer 11 is grown up by 300A thickness.

[0055] (p mold lightguide layer 11) continuing --  $\text{Cp}2$  -- p mold lightguide layer 11 which bandgap energy becomes from the undoping GaN smaller than p mold cap layer 10 at a stop and 1050 degrees C about Mg and TMA is grown up by 0.1-micrometer thickness.

[0056] (p mold cladding layer 12) then, the layer which consists of undoping aluminum $0.16\text{Ga}0.84\text{N}$  at 1050 degrees C is grown up by 25A thickness -- making -- continuing --  $\text{Cp}2$  -- the layer which consists Mg and TMA of a stop and undoping GaN is grown up by 25A thickness, and p mold cladding layer 12 which consists of a superlattice layer of the 0.6 micrometers of the total thickness is grown up.

[0057] (p mold contact layer 13) p mold contact layer 13 which finally consists of a p mold GaN which doped Mg  $1 \times 10^{20} \text{--}/\text{cm}^3$  on p mold cladding layer 9 at 1050 degrees C is grown up by 150A thickness.

[0058] The protective coat which becomes the front face of p mold contact layer of the ejection from a reaction container and the maximum upper layer from  $\text{SiO}_2$  about the wafer into which the nitride semi-conductor was grown up as mentioned above is formed, and it etches by  $\text{SiCl}_4$  gas using RIE (reactive ion etching), and as shown in drawing 2, the front face of n mold contact layer 5 which should form n electrode is exposed. Thus, for etching a nitride semi-conductor deeply, it considers as a protective coat, and  $\text{SiO}_2$  is the optimal.

[0059] Next, mostly, as shown in drawing 5 (a), after forming the 1st protective

coat 61 of p mold contact layer 13 of the maximum upper layer which consists of an Si oxide (mainly SiO<sub>2</sub>) by 0.5-micrometer thickness with PVD equipment, the mask of a predetermined configuration is covered on the 1st protective coat 61, and the 3rd protective coat 63 which consists of a photoresist is formed in the whole surface by 1 micrometer in stripe width of face of 2 micrometers, and thickness.

[0060] Next, as shown in drawing 5 (b), said 1st protective coat 61 is etched by using the 3rd protective coat 63 as a mask using CF<sub>4</sub> gas after the 3rd protective coat 63 formation and with RIE (reactive ion etching) equipment, and it considers as the shape of a stripe. By processing with an etching reagent after that and removing only a photoresist, as shown in drawing 5 (c), the 1st protective coat 61 with a stripe width of face of 2 micrometers can be formed on p mold contact layer 13.

[0061] Furthermore, as shown in drawing 5 (d), after the 1st protective coat 61 formation of the shape of a stripe, p mold contact layer 13 and p mold cladding layer 12 are again etched using SiCl<sub>4</sub> gas by RIE, and a stripe-like waveguide field (ridge stripe in this case) is formed. The transverse mode is [ that it is easy to become a single mode ] dramatically desirable when it is the configuration of an order mesa where the cross-section configuration of the stripe is shown in drawing 2, in case a stripe is formed.

[0062] Where the film for protecting so that a rich layer may not be formed in p mold contact layer 13, after forming the stripe of a ridge configuration is attached, on the flat surface which is continuing from the side face of the stripe of a ridge configuration, and its side face, aluminum is vapor-deposited with PVD equipment and the vacuum evaporation film is formed [ drawing 5 (e-1)]. Next, in an annealing furnace, it heat-treats by applying predetermined time amount and heat. Then, an acid removes the vacuum evaporation film of aluminum. Thus, the rich layer 201 is formed like drawing 5 (e-2).

[0063] A wafer is transported to PVD equipment after forming the rich layer 201, and as shown in drawing 5 (f), the 2nd protective coat 62 which consists of a Zr oxide (mainly ZrO<sub>2</sub>) is continued and formed by 0.5-micrometer thickness on p mold cladding layer 12 exposed by etching the 1st protective coat 61 top.

[0064] Next, as it is immersed in fluoric acid and a wafer is shown in drawing 5 (g), the 1st protective coat 61 is removed by the lift-off method.

[0065] Next, as shown in drawing 5 (h), the p electrode 20 which consists of nickel/Au is formed in the front face of the p mold contact layer which the 1st protective coat 61 on p mold contact layer 13 was removed, and was exposed. However, as stripe width of face of 100 micrometers, the p electrode 20 is gone across and formed on the 2nd protective coat 62, as shown in this drawing 5 (h).

[0066] Next, succeeding the whole surface on the p electrode 20, the 1st thin film layer 31 which consists of Ti is formed by 1000Å thickness, and as further shown in drawing 2, the 1st thin film layer 31 is formed in the side face of a stripe etc. The upper part of the magnitude which is not in agreement with the cleavage plane at the time of forming a resonance side by cleavage at a next process on this 1st thin film layer 31 formed continuously, i.e., the part used as a cleavage plane, is avoided, the 2nd thin film layer 32 which consists of Au intermittently is formed by

8000Å thickness, and p pad electrode 101 which consists of the 1st thin film layer 31 and the 2nd thin film layer 32 is formed.

[0067] The n electrode 21 which consists of Ti/aluminum is formed in the front face of n mold contact layer 5 exposed at the very first in a direction parallel to a stripe after p pad electrode formation, and n pad electrode which consists of Ti/Pt/Au is formed on it.

[0068] After grinding the silicon on sapphire of the wafer which formed n electrode, p electrode, and p pad electrode as mentioned above and being referred to as 70 micrometers, in a direction vertical to a stripe-like electrode, cleavage is carried out to the shape of a bar from a substrate side, and a resonator is produced to a cleavage plane (11 the 00th [ -] page, a hexagon head field = equivalent to the side face of a pillar-shaped crystal Mth page). The dielectric multilayer which consists of SiO<sub>2</sub> and TiO<sub>2</sub> is formed in a resonator side, and, finally it considers as a laser component as cut a bar and shown in drawing 2 in a direction parallel to p electrode. In addition, as for cavity length, it is desirable to be referred to as 300-500 micrometers.

[0069] When this laser component is installed in a heat sink, wire bonding of each electrode is carried out and laser oscillation is tried at a room temperature, in the oscillation wavelength of 400-420nm, and threshold-current consistency 2.9 kA/cm<sup>2</sup>, a room temperature shows a good continuous oscillation. Furthermore, leakage current and a short circuit can be prevented, a laser component with a good life property can be obtained efficiently, and the yield improves because insulation became good.

[0070] In the [example 2] example 1, the rich layer 201 which consists of aluminum is formed by the ion implantation, and also a laser component is produced similarly. As the approach of an ion implantation, it is in the condition which attached the protective coat to the maximum top face of p mold contact layer 13, and aluminum is accelerated from a wafer top face to predetermined energy with ion implantation equipment, and it is devoted to a wafer. Next, a carrier beam part is heat-treated and a damage is made to recrystallize by the ion implantation. The obtained laser component shows a good component property like an example 1, and its yield also improves further.

[0071] [Example 3] drawing 3 is the typical sectional view showing the structure of the laser component concerning other examples of this invention, and explains an example 3 below based on this drawing.

[0072] (Nitride semi-conductor substrate 40) In an example 1, a wafer is again set to the front face of the substrate layer 2 in the reaction container of MOVPE after stripe-like formation [ protective coat 3 ], temperature is made into 1050 degrees C, and Undoping GaN is grown up by 5-micrometer thickness using TMG and ammonia. Then, a wafer is transported to HVPE (hydride vapor growth) equipment, Ga metal, HCl gas, and ammonia are used for a raw material, and the nitride semi-conductor substrate 40 which consists of undoping GaN is grown up by 200-micrometer thickness. thus, MOVPE -- HVPE after growing up a nitride semi-conductor on a protective coat 3 by law -- if a GaN thick film 100 micrometers or more is grown up by law, even if it compares a crystal defect with an example 1, it will be acquired, and will decrease single or more figures. After nitride semi-

conductor substrate 40 growth, polish removes the ejection from a reaction container, silicon on sapphire 1, a buffer layer 2, a protective coat 3, and an undoping GaN layer, and let a wafer be independent [ nitride semi-conductor substrate 40 ].

[0073] The rest carries out the laminating even of n mold contact layer 5 – the p mold contact layer 13 on the nitride semi-conductor substrate 40 of an opposite hand a polish side like an example 1.

[0074] Like an example 1 after p mold contact layer 13 growth, let an etching stop be the front face of n mold contact layer 5 in the 2nd process after forming the stripe-like 1st protective coat 61. The rest forms an electrode in each contact layer, after forming in the side face of stripe waveguide, and the front face of n mold contact layer 5 the 2nd protective coat 62 which uses  $ZrO_2$  as a principal component after forming the rich layer 201 which consists of aluminum like an example 1. Next, p pad electrode 101 is formed like an example 1, and it considers as the laser component of structure as shown in drawing 3. In addition, when forming a resonance side, the cleavage plane of a nitride semi-conductor substrate may be the Mth same page as an example 1. A threshold-current consistency falls [ the obtained laser component ] even to 1.8 kA/cm<sup>2</sup> as compared with an example 1, a life can improve by 3 or more times, leakage current and a short circuit can prevent good by insulating improvement still like an example 1, and the laser component which has a good life property can be produced with the sufficient yield.

[0075] [Example 4] drawing 4 is the typical sectional view showing the structure of the laser component concerning other examples of this invention, and explains an example 4 using this drawing 4 below.

[0076] In an example 3, in case the nitride semi-conductor substrate 40 is produced, in HVPE equipment, silane gas is added to a raw material, and the nitride semi-conductor substrate 50 which consists of GaN which doped Si  $1 \times 10^{18}$ –/cm<sup>3</sup> is grown up by 200-micrometer thickness. In addition, as for Si concentration, it is desirable to consider as the range of three to  $5 \times 10^{19}$ /cm<sup>3</sup> of  $1 \times 10^{17}$ –/cm. Silicon on sapphire 1, a buffer layer 2, a protective coat 3, and an undoping GaN layer are ground and removed like an example 3 after nitride semi-conductor substrate 50 growth, and it considers as nitride semi-conductor substrate 50 simple substance.

[0077] Next, laminating growth even of the crack prevention layer 6 – the p mold contact layer 13 is carried out like an example 1 on this nitride semi-conductor substrate 50. Like an example 1 after p mold contact layer 13 growth, after forming the stripe-like 1st protective coat 61, in the 2nd process, it considers as the front face of n mold cladding layer 7 which shows an etching stop to drawing 5. Like an example 1, the rest forms the rich layer 201, and after that, after it forms in the side face of stripe waveguide, and the front face of n mold cladding layer 7 the 2nd protective coat 62 which uses  $ZrO_2$  as a principal component, it forms the p electrode 20 through the 2nd protective coat.

[0078] The 1st thin film layer 31 which consists of Ti on the p electrode 21 so that it may become stripe die length and the same die length next, by 1000Å of thickness The 3rd thin film layer which consists of Pt in the configuration of the 2nd thin film layer 32, and the same configuration by 1000Å of thickness And p pad

electrode 101 which comes to carry out laminating formation of the 2nd thin film layer 32 which consists of Au in a configuration shorter than stripe die length by 8000Å of thickness at order is formed as shown in drawing 4 . Although the 3rd thin film layer is not illustrated, it forms in the same configuration as the 2nd thin film layer. on the other hand -- the rear-face side of a nitride semi-conductor substrate -- the n electrode 21 is mostly formed in the whole surface. After electrode formation, cleavage is carried out by the Mth page of a nitride semi-conductor substrate, and a resonance side is produced and it considers as the laser component of structure as shown in drawing 4 .

[0079] [Example 5] As shown in the laser component of drawing 6 which shows the laser component indicated by said J.J.A.P. at drawing 1 , the laser component which comes to form the rich layer 201 like an example 1 is produced. Insulation can become good, and the obtained laser component can prevent generating of leakage current, and generating of a short circuit, and can produce a component with a good life property with the sufficient yield.

[0080] In the [example 6] example 1, the laser component which has it come to form the rich layer 201 which change to aluminum, and B is used, and also contains B in abundance by diffusion similarly is produced. Consequently, a good result almost equivalent to an example 1 is obtained.

[0081] In the [example 7] example 2, the laser component which has it come to form the rich layer 201 which change to aluminum, and B is used, and also contains B in abundance by the ion implantation similarly is produced. Consequently, a good result almost equivalent to an example 1 is obtained.

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[Translation done.]

## \* NOTICES \*

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1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.\*\*\* shows the word which can not be translated.

3.In the drawings, any words are not translated.

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## DESCRIPTION OF DRAWINGS

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### [Brief Description of the Drawings]

[Drawing 1] It is the typical sectional view showing a part of nitride semiconductor laser component concerning the gestalt of 1 operation of this invention.

[Drawing 2] It is the typical sectional view of the nitride semiconductor laser component concerning the gestalt of 1 operation of this invention.

[Drawing 3] It is the typical sectional view of the nitride semiconductor laser component concerning the gestalt of 1 operation of this invention.

[Drawing 4] It is the typical sectional view of the nitride semiconductor laser component concerning the gestalt of 1 operation of this invention.

[Drawing 5] It is the typical sectional view showing the partial structure of the wafer in each process for explaining each process of the approach of forming the stripe of the ridge configuration of drawing 2 - drawing 4 etc.

[Drawing 6] It is the typical sectional view showing the structure of the conventional laser component.

### [Description of Notations]

1 ... Different-species substrate

2 ... Substrate layer

3 ... Protective coat for nitride semi-conductor substrate growth

4, 40, 50 ... Nitride semi-conductor substrate

5 ... n mold contact layer

6 ... Crack prevention layer

7 ... n mold cladding layer

8 ... n mold lightguide layer

9 ... Barrier layer

10 ... p mold cap layer

11 ... p mold lightguide layer

12 ... p mold cladding layer

13 ... p mold contact layer

15 ... Insulator layer

61 ... The 1st protective coat

62 ... The 2nd protective coat

63 ... The 3rd protective coat

20 ... p electrode

21 ... n electrode

31 ... 1st thin film layer  
32... 2nd thin film layer  
101 ... Pad electrode  
201 ... Rich layer

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[Translation done.]



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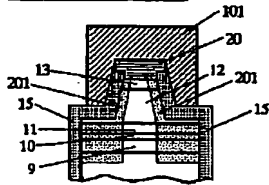
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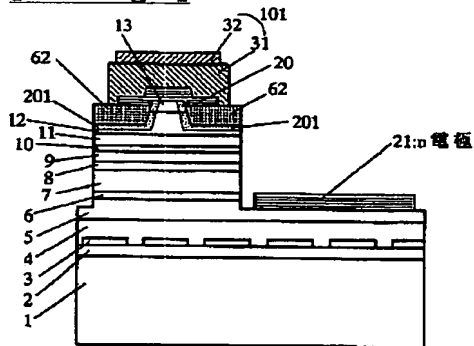
3.In the drawings, any words are not translated.

## DRAWINGS

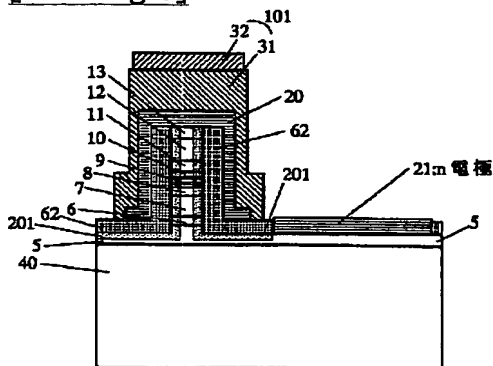
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Drawing 4]



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[Translation done.]